

# Relationship Between Energy Balance-Related Behaviors and Its Influencing Factors in Overweight/Obese Primary School Students Aged 10–12 Years in China

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## Research Article

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## Abstract

**Background:** Energy balance-related behaviors (EBRBs) are behaviors closely related to energy intake and expenditure. Unhealthy EBRBs are closely related to overweight and obesity in primary school students, and personal and family factors are the key factors that affect the EBRBs of primary school students.

**Methods:** In order to explore the relationship between EBRBs, related factors, and overweight and obesity among school-age children, the body mass index of 4,412 10–12-year-olds from North China, Northeast China, Northwest China, and Southwest China was measured, and they were assessed using a questionnaire regarding EBRBs and influencing factors.

### Results:

1. Compared with normal-weight students, the number of breakfasts consumed per week by overweight/obese students was significantly higher ( $p < 0.01$ ), and the weekly screen-viewing time was significantly longer ( $p < 0.01$ ).

2. There are some differences in influencing factors of EBRBs between overweight/obese pupils and normal weight pupils. Overweight/obese students' health beliefs, parental subjective norms, parental modelling, parental practices, and home availability scores increased significantly in terms of beverage consumption behavior ( $p < 0.01$  or  $p < 0.05$ ). The scores of attitude, health beliefs, self-efficacy, parental subjective norms and active encouragement decreased significantly in terms of breakfast consumption ( $p < 0.01$  or  $p < 0.05$ ). The health beliefs scores of physical activity increased significantly ( $p < 0.01$ ), and preference and autonomy scores decreased significantly ( $p < 0.01$ ). The health beliefs, parental subjective norms and parental practices scores of screen-viewing activities increased significantly ( $p < 0.01$  or  $p < 0.05$ ).

3. Breakfast consumption (odds ratio [OR]: 0.911; 95% confidence interval [CI]: 0.870–0.954) and screen-viewing activities (OR: 1.055; 95% CI: 1.030–1.080) were negatively correlated and positively correlated with overweight/obesity, respectively.

4. Factors that significantly influenced weekly breakfast consumption included attitude, health beliefs, self-efficacy, parental subjective norms, and active encouragement. The main factors that influenced weekly screen-viewing time were parental practices, self-efficacy, preference, attitude, autonomy, and parental modelling.

**Conclusions:** Irregular breakfast consumption and excessive screen-viewing time engagement are key EBRBs associated with overweight/obesity among Chinese primary school students aged 10–12 years. Unhealthy breakfast consumption and screen-viewing activities of overweight/obese students are associated with an interaction between individual and family factors.

## Background

Overweight and obesity are conditions that not only affect the growth, development, and physical and mental health of school-age children, but also increase the risk of several diseases in adulthood<sup>[1–3]</sup>. According to statistics published by the World Health Organization in 2016, the number of overweight and obese children aged 5–19 years had exceeded 340 million worldwide, representing more than 18% of the total global population of school-age children<sup>[4]</sup>. China is the world's most populous country, accounting for approximately one-fifth of the total global population. Over the past 40 years, the Chinese economy has developed rapidly; during this time, the total number of obese individuals in China has continued to grow, now ranking first in the world<sup>[5]</sup>. The 2020 Report on Nutrition and Chronic Diseases of Chinese Residents showed that the overweight and obesity rate of children and adolescents in China had rapidly increased from 6.6% in 2002 to 19.0% in 2020<sup>[6]</sup>. Thus, overweight and obesity have become a prominent health problem in school-age children in China, and there is an urgent need to identify the causes of overweight and obesity in children in order to develop effective intervention methods.

The primary problem in conditions of overweight and obesity is excess energy intake. Unhealthy eating habits can result in increased energy intake, and sedentary behavior can reduce energy consumption. The joint effect of these two factors results in a positive energy balance, and long-term excess energy intake causes excessive accumulation of lipids in the body, resulting in overweight or obesity<sup>[7]</sup>. Studies have shown that overweight and obesity in school-age children are related to unhealthy lifestyle behaviors, including consuming sugary beverages<sup>[8]</sup>, skipping breakfast<sup>[9]</sup>, low physical activity levels<sup>[10]</sup>, and extended engagement with sedentary forms of entertainment, such as television or video games<sup>[11]</sup>. Since these behaviors affect energy balance, they are called energy balance-related behaviors (EBRBs). EBRBs are influenced by many factors, among which children's individual and family factors are the most important<sup>[12]</sup>.

Research on EBRBs and their influencing factors in school-age children in Europe began with the study “European Energy balance Research to prevent excessive weight Gain among Youth (ENERGY)”<sup>[13]</sup> that investigated overweight and obesity, EBRBs, and their influencing factors in school-age children aged 10–12 years in eight European countries by means of biometric measurements and questionnaire responses. The results of this study showed that the overweight and obesity rates of boys and girls aged 10–12 years in Europe were higher than the world average, at 34.6% and 26.8%, respectively. While unhealthy eating behaviors, lack of physical activity, and extended periods of sitting are all related to overweight and obesity, there are some differences in these EBRBs<sup>[14]</sup> and their influencing factors<sup>[12]</sup> among children in different countries. However, most children in these countries have unhealthy behaviors such as sugary beverage consumption and engagement with sedentary forms of entertainment, such as television or video games, and they also lack knowledge regarding healthy behaviors<sup>[12]</sup>. Parents<sup>[15–19]</sup> play an important role in influencing these behaviors in children and educating them about healthy EBRBs<sup>[20]</sup>.

China covers a vast territory and comprises a large population, and the overweight and obesity rate of school-age children continues to increase. Although there have been many investigations on the causes of overweight and obesity among children, most of these studies have focused on the relationship

between a single behavior and overweight and obesity and its influencing factors in individual geographical areas<sup>[21–24]</sup>. There is a lack of nationwide systematic studies on these topics; at present, deep correlations between children's overweight or obesity status and EBRBs and their influencing factors have not been rigorously investigated. Energy balance is influenced by many related behaviors, and EBRBs are the result of many factors<sup>[25]</sup>; therefore, research on the relationship between overweight and obesity and EBRBs and their influencing factors must be conducted in a manner that considers multiple dimensions in order to comprehensively and systematically determine the key behaviors and influencing factors that affect overweight and obesity in school-age children.

School-age children aged 10–12 years are in a critical period of growth, development, and behavior formation, and individual and family factors play key roles in influencing their behavior. In this study, BMI grade tests and EBRBs and their influencing factors were assessed in school-age children aged 10–12 years in North China, Northeast China, Northwest China, and Southwest China. Differences between these regions and relationships between overweight/obesity, EBRBs and their influencing factors in primary school students in China were explored to provide a theoretical reference and practical guidance for formulating effective measures to prevent and control overweight/obesity among school-age children.

## Methods

### Participants

According to the geographical location and economic development, and following the principle of stratified sampling, one province was selected from North China, Northeast China, Northwest China, and Southwest China. From each province, eight administrative regions were selected, and from each administrative region, one urban primary school and one township primary school were selected. Each primary school selected 90–108 students from grades 4–6 (10–12 years old; 30–36 students in each grade), comprising an equal number of male and female students. After excluding students with abnormal growth and development and major diseases, 4,608 students remained, which included 1,102 from North China, 1,114 from Northeast China, 1,096 from Northwest China, and 1,100 from South China. After excluding participants with incomplete, invalid data and low-weight children, 4,412 (2,199 boys and 2,213 girls) children remained and were included in the present analysis.

### Assessment

The study assessment comprised of the following two parts:

1. Height and weight were measured according to the National Student Physical Health Standard (revised in 2014) issued by the Ministry of Education of the People's Republic of China to screen children for overweight and obesity (see Additional file 1). Normal-weight students were used as a reference group, and overweight and obese students from each grade were combined into the overweight/obese group. The number of underweight primary school students was small, accounting for only 2.80% of the total sample; therefore, this group was not included in the present analysis.

2. Questionnaires were used to investigate pupils' EBRBs and their influencing factors. The questionnaire refers to the Children's questionnaire in the "European Energy balance Research to prevent excessive weight Gain among Youth (ENERGY) project: Design and methodology of the ENERGY cross-sectional survey". Experts in the field were consulted, and questionnaire contents were revised according to expert opinions and China's national conditions. The reliability and validity of the modified questionnaire were then tested. The Cronbach reliability coefficient of the questionnaire was 0.734, and the validity of the KMO and Bartlett sphere test was 0.910. Questionnaires were completed independently by primary school students under the unified guidance of professionals, then immediately collected by the professionals. The questionnaire recovery rate was 100%.

This study conducted a questionnaire survey of primary school students' EBRBs and their influencing factors and calculated the number of beverages consumed, and the amount of breakfasts, physical activity, and screen-viewing time within a week. Individual factors related to EBRBs were assessed using questions related to personal attitudes and beliefs regarding health practices, individual preferences, self-efficacy, and autonomy. Family factors were assessed with questions related to parental subjective norms, parental modelling, home availability, parental practices, and active parental encouragement (see Additional file 2).

### Data analysis

Data concerning EBRBs (e.g., beverage consumption, breakfast consumption, physical activity, and screen-viewing behavior) and their influencing factors (e.g., individual and family factors) of participants in the normoweight and overweight/obese groups were tested using an independent sample t-test. Logistic regression was used to analyze the relationship between overweight/obese students' EBRBs, and linear regression was used to analyze the relationship between EBRBs and their influencing factors.

## Results

A total of 4,412 children aged 10–12 years participated in this study. Table 1 shows the number and proportion of students in each weight grade. Among the study participants, there were 1,156 overweight/obese students and 3,134 normoweight students, with an overweight/obese rate of 26.2%. The average BMI of overweight/obese students was  $23.42 \pm 0.10$  kg/m<sup>2</sup> and that of normoweight students was  $17.14 \pm 0.03$  kg/m<sup>2</sup>.

Table 1  
Number and proportion of Chinese primary school students aged 10-12 in different weight grades (n=4412)

Weight grade	Boys	Girls	Entirety
obesity	297(13.5%)	228(10.3%)	525(11.9%)
overweight	335(15.2%)	296(13.4%)	631(14.3%)
normal	1503(68.4%)	1631(73.7%)	3134(71.0%)
low weight	64(2.9%)	58(2.6%)	122(2.8%)
total	2199	2213	4412

**Differences in EBRBs between overweight/obese and normoweight students aged 10–12 years in China**

Table 2 displays the results of the EBRB-related questionnaire and shows the differences in EBRBs between overweight/obese and normoweight students. There were no differences in beverage consumption and physical activity between the two groups ( $p > 0.05$ ); however, breakfast consumption was significantly lower in the overweight/obese group than in the normoweight group ( $p < 0.01$ ). Further, reported screen time engagement was significantly higher in the overweight/obese group than in the normoweight group ( $p < 0.01$ ). Differences in EBRBs according to sex were consistent with differences for each group at the overall level.

Table 2  
Differences of EBRBs between overweight/obesity and normal weight Chinese primary school aged 10-12 years (n=4290)

	Entirety(n=4290)		Boys(n=2135)		Girls(n=2155)	
	Normal $\bar{x} \pm SE$	Overweight/Obesity $\bar{x} \pm SE$	Normal $\bar{x} \pm SE$	Overweight/Obesity $\bar{x} \pm SE$	Normal $\bar{x} \pm SE$	Overweight/Obesity $\bar{x} \pm SE$
Beverage behavior	1.17±0.02	1.22±0.04	1.34±0.04	1.30±0.06	1.02±0.03	1.11±0.05
Breakfast behavior	6.31±0.02	6.09±0.05**	6.26±0.04	6.13±0.06*	6.36±0.03	6.06±0.07**
Physical activity	4.43±0.05	4.51±0.08	4.76±0.08	4.67±0.12	4.12±0.07	4.32±0.12
Video behavior	2.81±0.05	3.26±0.09**	3.18±0.07	3.54±0.12*	2.47±0.06	2.93±0.12**

Note: \* means there is significant difference at 0.05 level, \*\* means there is significant difference at 0.01 level.

**Differences in EBRB influencing factors between overweight/obese and normoweight students aged 10–12 years in China**

Differences in EBRB influencing factors between the overweight/obese and normoweight groups are shown in Table 3. The scores for beverage consumption influencing factors, "Health beliefs," "Parental subjective norm," "Parent modelling," "Parental practices," and "Home availability," were significantly increased in the overweight/obese group compared to the normoweight group ( $p < 0.01$  or  $p < 0.05$ ). Overweight/obese boys' scores for "Health beliefs," "Self-efficacy," "Parental subjective norm," and "Parent modelling" were significantly increased compared to the normoweight boys' scores ( $p < 0.01$  or  $p < 0.05$ ), while the overweight/obese girls' scores for "Health beliefs," "Parental subjective norm," "Parent modelling," and "Home availability" were significantly increased compared to the scores of normoweight girls ( $p < 0.01$  or  $p < 0.05$ ).

Factors influencing breakfast consumption, including scores for survey questions assessing "Attitude," "Health beliefs," "Self-efficacy," "Parental subjective norm," and "Parental support," of overweight/obese students were significantly lower than those in the normoweight group ( $p < 0.01$  or  $p < 0.05$ ). Scores related to "Health beliefs" of obese/overweight boys were significantly lower than those of normoweight boys ( $p < 0.01$ ). Obese/overweight girls' scores related to "Health beliefs," "Preferences," "Self-efficacy," "Parental subjective norm," and "Parental support" were significantly lower than those of normoweight girls ( $p < 0.01$  or  $p < 0.05$ ).

Influencing factors of physical activity, including "Health beliefs" scores, were significantly higher in the overweight/obese group than in the normoweight group ( $p < 0.01$ ), and the scores for items assessing "Preference" and "Autonomy" were significantly lower ( $p < 0.01$ ). The scores of overweight/obese boys concerning "Health beliefs" and "Parental subjective norms" were significantly higher than those of normoweight boys ( $p < 0.01$  or  $p < 0.05$ ), while scores related to "Preference" and "Autonomy" were significantly lower ( $p < 0.05$ ). The scores of overweight/obese girls related to "Health beliefs" was significantly higher than those of normoweight girls ( $p < 0.01$ ), while the scores related to "Preference" were significantly lower ( $p < 0.01$ ).

Influencing factors of screen-viewing behavior including "Health beliefs," "Parental subjective norms," and "Parental practices" were significantly higher in overweight/obese students than in the normoweight group ( $p < 0.01$  or  $p < 0.05$ ). Overweight/obese boys' scores related to "Health beliefs," "Self-efficacy," "Parental subjective norms," and "Parental practices" were significantly higher than those of normoweight boys ( $p < 0.01$  or  $p < 0.05$ ). Overweight/obese girls' scores related to "Health beliefs" and "Parental practices" were significantly higher than those of normoweight girls ( $p < 0.05$ ).

Table 3  
Differences of EBRBS influencing factors between overweight/obesity and normal weight Chinese primary school aged 10-12 years in China (n=4290)

			Entirety(n=4290)		Boys(n=2135)		Girls(n=2155)	
			Normal	Overweight/Obesity	Normal	Overweight/Obesity	Normal	Overweight
			$\bar{x}\pm SE$	$\bar{x}\pm SE$	$\bar{x}\pm SE$	$\bar{x}\pm SE$	$\bar{x}\pm SE$	$\bar{x}\pm SE$
Beverage behavior	Personal variables	Health beliefs	3.85±0.02	4.27±0.03**	3.76±0.03	4.22±0.04**	3.93±0.03	4.33±0.04'
		Family environmental variables	Parental subjective norm	2.34±0.02	2.48±0.04**	2.35±0.03	2.48±0.06**	2.33±0.03
	Parent modelling		2.47±0.02	2.62±0.04**	2.49±0.03	2.60±0.05*	2.44±0.03	2.65±0.05'
	parental practices		2.50±0.02	2.59±0.04*	2.48±0.03	2.56±0.05	2.51±0.03	2.62±0.05
	Home availability	2.42±0.02	2.56±0.04**	2.45±0.03	2.56±0.05	2.39±0.03	2.57±0.05'	
Breakfast behavior	Personal variables	Attitude	4.67±0.01	4.61±0.02*	4.63±0.02	4.59±0.03	4.70±0.02	4.63±0.03
		Health beliefs	3.37±0.03	3.10±0.04**	3.31±0.04	3.06±0.06**	3.43±0.03	3.15±0.06'
		Self-efficacy	4.63±0.01	4.58±0.02*	4.59±0.02	4.60±0.03	4.67±0.02	4.55±0.03'
	Family environmental variables	Parental subjective norm	4.69±0.01	4.60±0.02**	4.64±0.02	4.59±0.03	4.73±0.02	4.60±0.03'
		Active encouragement/parental support	4.64±0.02	4.54±0.03**	4.59±0.02	4.53±0.04	4.69±0.02	4.54±0.04'
Physical activity	Personal variables	Health beliefs	3.88±0.02	4.24±0.04**	3.87±0.04	4.26±0.05**	3.88±0.03	4.22±0.05'
		Preference/liking	4.62±0.01	4.50±0.02**	4.67±0.02	4.54±0.03*	4.56±0.02	4.45±0.04'
		Automaticity	4.48±0.02	4.38±0.03**	4.54±0.02	4.41±0.04*	4.42±0.02	4.35±0.04
Video behavior	Personal variables	Health beliefs	2.85±0.03	3.06±0.05**	2.78±0.04	3.02±0.07**	2.91±0.04	3.11±0.07'
		Family environmental variables	Parental subjective norm	2.24±0.02	2.28±0.03*	2.29±0.03	2.32±0.05*	2.19±0.03
	parental practices		2.33±0.02	2.46±0.04*	2.40±0.03	2.49±0.05*	2.26±0.03	2.44±0.05'

Note: \* means there is significant difference at 0.05 level, \*\* means there is significant difference at 0.01 level.

## Relationship between overweight/obesity and EBRBs in Chinese primary school students aged 10–12 years

Multivariate logistic analysis was used to analyze the relationship between overweight/obesity and EBRBs (beverage consumption behavior, breakfast consumption behavior, physical activity, and screen-viewing behavior). Results are shown below in Table 4. Breakfast consumption behavior (odds ratio [OR]: 0.911, confidence interval [CI]: 0.870–0.954) and screen-viewing behavior (OR: 1.055, CI: 1.030–1.080) were independent factors affecting overweight/obesity. Regular breakfast consumption behavior was associated with a reduced risk of overweight/obesity, and increasing the number of breakfasts consumed by one additional breakfast per week reduced the risk of overweight/obesity by 9%; in girls, the risk was reduced by 13.3%. Increased screen-viewing time was associated with an increased risk of overweight/obesity; for every additional hour of screen time per week, the risk of overweight/obesity increased by 5.5% (4.2% for boys and 6.9% for girls).

Table 4  
Results of EBRBs Logistic regression analysis between overweight/obesity and primary school students aged 10-12 years in China (n=4290)

	Entirety(n=4290)				Boys(n=2135)				Girls(n=2155)			
	B	p	OR	95%CI	B	p	OR	95%CI	B	p	OR	95%CI
Breakfast behavior	-0.094	0.000	0.911	0.870-0.954					-0.143	0.000	0.867	0.810-0.928
Video behavior	0.053	0.000	1.055	1.030-1.080	0.041	0.000	1.042	1.010-1.074	0.066	0.001	1.069	1.028-1.111
constant	-0.578	0.000	0.561		-1.003	0.000	0.367		-0.428	0.063	0.652	

Note: B represents the non-standardized coefficient, P represents the significance, OR represents the odds ratio and 95%CI represents the 95% confidence interval.

**Relationship between breakfast consumption behavior and influencing factors among overweight/obese primary school students aged 10–12 years in China**

For linear regression analysis, the number of breakfasts consumed per week by overweight/obese students were taken as dependent variables, and personal and family factors were taken as independent variables. The results of this analysis are shown in Table 5. According to the significance and standardization coefficient, the main influencing factors of the number of breakfasts consumed per week by overweight/obese students were self-efficacy, parental modelling, preference, home availability, attitude, and health beliefs. The main influencing factors of the number of breakfasts consumed per week by boys were self-efficacy, preference, parental modelling, attitude, and home availability. The main influencing factors of the number of breakfasts consumed per week by girls were preference, home availability, parental modelling, self-efficacy, and health beliefs. All factors positively correlated with the number of breakfasts consumed per week by primary school students.

Table 5

The results of linear regression analysis between breakfast consumption and influencing factors of overweight/obese primary school students aged 10-12 years in China (n=1156)

		Entirety(n=1156)			Boys(n=632)			Girls(n=524)					
		B	SE	p			B	SE	p				
		Constant	1.595	0.176	0.000	constant	1.244	0.235	0.000	constant	2.26	0.238	0.00
Personal variables	Self-efficacy	0.284	0.036	0.000	Self-efficacy	0.37	0.049	0.000	Preference/liking	0.227	0.051	0.00	
	Preference/liking	0.197	0.036	0.000	Preference/liking	0.198	0.048	0.000	Self-efficacy	0.186	0.051	0.00	
	Attitude	0.121	0.036	0.001	Attitude	0.188	0.047	0.000	Health beliefs	0.057	0.02	0.00	
	Health beliefs	0.049	0.014	0.001									
Family environmental variables	Parent modelling	0.206	0.026	0.000	Parent modelling	0.19	0.037	0.000	Home availability	0.217	0.032	0.00	
	Home availability	0.184	0.023	0.000	Home availability	0.152	0.032	0.000	Parent modelling	0.217	0.036	0.00	

Note: B represents the non-standardized coefficient, SE represents the standard error, P represents the significance.

Linear regression analysis was conducted with overweight/obese students' weekly screen-viewing time as the dependent variable and personal and family factors as independent variables. The results of this analysis are shown in Table 6. The main influencing factors of the overweight/obese students' weekly screen-viewing time were parental practices, self-efficacy, preference, attitude, autonomy, and parental modelling. The main influencing factors of boys' weekly screen-viewing time were parental practices, preference, attitude, self-efficacy, autonomy, and parental modelling. The main influencing factors of girls' weekly screen viewing time were parental practices, self-efficacy, autonomy, preference, and attitude. Self-efficacy was negatively correlated with weekly screen-viewing time, while the other factors were positively correlated with weekly screen-viewing time.

Table 6

Results of linear regression analysis on the screen-viewing activities and influencing factors of overweight/obese primary school students aged 10-12 years in China (n=1156)

		Entirety(n=1156)			Boys(n=632)			Girls(n=524)					
		B	SE	p			B	SE	p				
		Constant	0.552	0.277	0.047	Constant	0.397	0.395	0.316	Constant	1.13	0.372	0.0
Personal variables	Self-efficacy	-0.287	0.045	0.000	Preference/liking	0.325	0.083	0.000	Self-efficacy	-0.305	0.061	0.0	
	Preference/liking	0.265	0.056	0.000	Attitude	0.308	0.086	0.000	Automaticity	0.235	0.073	0.0	
	Attitude	0.254	0.058	0.000	Self-efficacy	-0.28	0.066	0.000	Preference/liking	0.206	0.075	0.0	
	Automaticity	0.249	0.055	0.000	Automaticity	0.265	0.083	0.001	Attitude	0.204	0.076	0.0	
Family environmental variables	Parental practices	0.377	0.047	0.000	Parental practices	0.342	0.069	0.000	Parental practices	0.414	0.061	0.0	
	Parent modelling	0.183	0.049	0.000	Parent modelling	0.209	0.071	0.003					

Note: B represents the non-standardized coefficient, SE represents the standard error, P represents the significance.

**Discussion**

In this study, the overweight/obesity rate of students aged 10–12 years was 26.2%, among which the overweight/obesity rates of boys and girls were 28.7% and 23.7%, respectively. Unhealthy EBRBs were significantly higher in overweight/obese students than in normoweight students; overweight/obese students

consumed fewer breakfasts per week and had increased weekly screen-viewing time relative to normoweight students. Poor breakfast consumption and screen-viewing activities were resultant of interactions between individual and family factors.

Regular consumption of high-quality breakfast has positive effects on child growth and development [26] and cognition and learning [27], but school-age children often skip breakfast for various reasons [28]. In this study, 71.8% of normoweight students reported that they consumed breakfast every day, while only 66.6% of overweight/obese students reported daily breakfast consumption. Further, the breakfast consumption frequency of normoweight students was significantly higher than that of overweight/obese students. Additionally, logistic regression analysis of children's breakfast consumption behavior and overweight/obesity status showed that weekly breakfast frequency was negatively correlated with overweight/obesity. This suggests that regular breakfast consumption behavior is associated with a reduced risk of overweight/obesity, whereas skipping breakfast is associated with an increased risk. This result is counterintuitive; from an energy balance perspective, it seems that skipping breakfast would result in decreased energy intake, reducing the risk of overweight/obesity. However, skipping breakfast is associated with an increased risk of overweight/obesity [29–31]. Indeed, studies have shown that while skipping breakfast reduces total energy intake [32], it is also correlated with reduced physical activity [33] and total energy expenditure [34]; therefore, the reduction in energy expenditure caused by skipping breakfast may be the reason for overweight/obesity. Our findings agree with previous results that indicate an association between skipping breakfast and an increased risk of overweight/obesity.

The linear regression model of overweight/obese students' breakfast consumption behavior and influencing factors used in this study indicated that irregular breakfast consumption behavior of overweight/obese students is the result of the joint action of individual and family factors. Among these factors, the influence of health beliefs, attitudes, preferences, and self-efficacy were important factors affecting breakfast consumption. At the same time, overweight/obese students had poorer scores regarding attitudes, health beliefs, and self-efficacy compared with normoweight students. Thus, it appears that insufficient knowledge concerning the health-related benefits of regularly eating breakfast may result in students skipping breakfast, increasing the risk of overweight/obesity. Additionally, overweight/obese students may mistakenly believe that skipping breakfast can help them reduce their weight, resulting in decreased self-efficacy. Studies have shown that parents can help prevent unhealthy eating behaviors in their children [35], and that if parents regularly consume breakfast and provide breakfast to their children, they can effectively prevent their children from skipping breakfast [36]. The present study demonstrates that parental modelling and sufficient availability of breakfast at home are important family factors that promote regular breakfast consumption in school-age children. However, the difference analysis indicated that there was no difference in parental modelling and home availability between overweight/obese and normoweight students. Thus, it can be concluded that the irregular breakfast consumption behaviors of overweight/obese students are mainly related to individual factors, while the influence of family factors is relatively weak. However, the influence of family factors may not be limited to direct effects. Therefore, this study conducted a correlation analysis between family and individual factors. The results of this correlation analysis showed that there is a correlation between parental subordinate norms, parental modelling, home availability, active assurance, and parental practices in family factors, and a correlation between attitudes, preferences, and self-efficacy in individual factors (see Additional file 3). Family factors may also indirectly affect students' breakfast consumption behaviors by influencing individual factors. Together, these results suggest that irregular breakfast consumption behavior is the key EBRB that influences the risk of overweight/obesity in primary school students, and that while unhealthy breakfast consumption behavior is the joint result of individual and family factors, individual factors have a greater influence on this risk.

Sedentary behavior refers to any conscious behavior with an energy consumption of  $\leq 1.5$  METs conducted in a sitting or leaning posture [37]. Screen-viewing activities (e.g., watching television, playing videogames, and browsing the internet) represents a common form of sedentary behavior among primary school students. In this study, the weekly screen-viewing time of overweight/obese students was significantly higher than that of normoweight students. Furthermore, logistic regression analysis showed that the weekly screen-viewing time was positively correlated with overweight/obesity. This suggests that a high weekly screen-viewing time is associated with an increased risk of overweight/obesity. Some studies have shown only a small negative correlation between sedentary behavior and physical activity, indicating that these activities do not replace one another and that screen-viewing time can be balanced with appropriate physical activity [38]. However, other studies have found that long-term high weekly screen-viewing time behavior was associated with an increased risk of overweight/obesity in school-age children [39–42]. This may be related to changes in diet and sleep behavior induced by excessive screen-viewing time engagement, in addition to increased sedentary behavior [43]. Excessive screen-viewing activities are associated with an increased consumption of convenience foods, such as prepared snacks and sugary beverages, and a reduced consumption of healthy foods, such as nutrient-dense foods, fruits, and vegetables [44]. Additionally, excessive screen-viewing activities are also associated with sleep deprivation [42], which is associated with an increased risk of overweight/obesity. The linear regression model of overweight/obese primary school students' weekly screen-viewing time and influencing factors showed that the weekly screen-viewing activities of overweight/obese primary school students during their growth period is influenced by an interaction between individual and family factors. Among these factors, autonomy, attitude, preference, and self-efficiency are important factors affecting screen-viewing activities. At the same time, the difference analysis showed that overweight/obese students have a better idea of the negative impact of screen-viewing activities on their health than normoweight students. However, the weekly screen-viewing time of overweight/obese students has not been reduced. Strict family rules [45] and good parental role models [46] can effectively reduce weekly screen-viewing time in children. The difference analysis showed that there is no difference between normoweight and overweight/obese students' parental subjective norms; on the contrary, there is a significant difference between parental practices.

Overweight/obese students have longer weekly screen-viewing times due to a lack of parental restrictions. In addition, family factors, such as parental subordinate norms, parent modelling, and parental practices are related to individual factors, such as attitudes, preferences, and autonomy in personal factors (see Additional file 4). This indicates that family factors not only directly affect screen-viewing activities in children but also indirectly affect screen-viewing activities by influencing children's individual factors. Together, these results suggest that excessive screen-viewing time is an important EBRB associated with overweight/obesity in primary school students, and that while this negative EBRB is the result of both individual and family factors, family rules are the most important.

Although many studies have shown that the consumption of sugary beverages<sup>[47]</sup> and low-level physical activity<sup>[10]</sup> are associated with an increased risk of overweight/obesity, the present study found no differences in sugary beverage consumption and physical activity between overweight/obese and normoweight students. Additionally, correlation analysis did not show that these two EBRBs are related to overweight/obesity in school-age children. Children's access to sugary beverages is largely controlled by their parents; and in this study, there is no difference in family factors between normoweight and overweight /obese students, which may be the reason for the lack of difference between sugary beverage consumption and physical activity between the two groups. In addition, the influence of family factors on physical activity were virtually the same among overweight/obese and normoweight students. Among the individual factors assessed for physical activity, normoweight students scored better on items related to health but scored worse on items related to preference and autonomy. There may be a comprehensive effect between these factors, resulting in no net differences in physical activity between the two groups.

## Limitations

The assessment of sugary beverage consumption may have been limited by the weak understanding that children aged 10–12 years have concerning the measurement units of beverages. Thus, using this survey-based approach, it was impossible to calculate the specific beverage intake. The indirect influence of family factors on EBRBs only confirms the relationship between family and individual factors but lacks direct evidence to establish an intermediary effect between family factors and EBRBs. There is an inevitable deviation between retrospective self-reports and reflecting the role of family factors from the perspective of students.

## Conclusions

Irregular breakfast consumption and excessive screen-viewing time are key EBRBs related to overweight/obesity among Chinese primary school students aged 10–12 years. Moreover, irregular breakfast consumption and excessive screen-viewing time in overweight/obese students are influenced by an interaction between individual and family factors.

## Abbreviations

EBRBs  
energy balance-related behaviors

## Declarations

**Ethics approval and consent to participate:** This study was approved by the Ethics Committee of Shenyang Sport University (No. 2020[19]) and was conducted according to the tenets of the Helsinki Declaration and its later amendments. All subjects and their parents signed a written informed consent.

**Consent for publication:** Not applicable.

**Availability of data and materials:** The datasets used and analysed during the current study cannot be shared at this time as the data also forms part of an ongoing study. If there is any need, please contact the author (Professor Bo CHANG - email address: changbo8387@163.com).

**Competing interests:** The authors declare they have no conflict of interest.

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**Authors' contributions:** Shicheng Zhang organized and summarized the data, and drafted the manuscript. Haining Gao, Ying Cui, Xin Wang, Wenshuo Cao participated in the data collection in North China, Northeast China, Northwest China and Southwest China respectively. Qian Ding made a statistical analysis of the data of this study. Bo Chang conceived of the study, and participated in its design and coordination. All authors read and approved the final manuscript.

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