Letter to the Editor

Energy Balance-related Behaviors Are Related to Cardiometabolic Parameters and Predict Adiposity in 8-14-year-old Overweight Chinese Children One Year Later*

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To identify target energy balance-related behaviors (ERBs), baseline data from 141 overweight or obese schoolchildren (aged 8-14 years old) was used to predict adiposity [body mass index (BMI) and fat percentage] one year later. The ERBs included a modified Dietary Approach to Stop Hypertension diet score (DASH score), leisure-time physical activity (PA, days/week), and leisure screen time (minutes/day). Several cardiometabolic variables were measured in the fasting state, including systolic blood pressure (SBP), diastolic blood pressure (DBP), blood glucose (GLU), total cholesterol (TC), triglycerides (TG), low-density lipoprotein (LDL-C), and high-density lipoprotein (HDL-C). BMI and fat percentage were measured using a BIA body composition analyzer (MC-980MA, TANITA, Tanita Co., Guangzhou, China). Partial correlation coefficients (partial *r*) and multiple linear regression models were used to predict BMI and fat percentage one year later. Our sample consisted of 114 boys and 83 girls with a mean BMI of 24.7±3.7 kg/m^2 and fat percentage of 34.2%±8.3% at baseline. BMI, fat percentage, and certain cardiometabolic variables were negatively associated with DASH score and leisure-time PA (all *P*<0.05), but positively associated with leisure screen time (all *P*<0.05) at baseline. Statistically significant predictors of BMI and fat percentage one year later were baseline BMI (partial *r*=0.85), fat percentage (partial *r*=0.69), eating out (times/week, partial *r*=0.18), and DASH Score (partial *r*=-0.18). Overall, childhood obesity prevention interventions should target reductions in ERBs.

Childhood obesity is a major contributor to many serious health conditions that increase morbidity and mortality, and it has increased at least three-fold in China over the past several decades[1-2]. The obesity epidemic among children is the result of excess energy intake and inadequate energy expenditure[3]. A meta-analysis showed that interventions targeting energy-balance-related behaviors (ERBs) result in clinically significant decreases in body mass index (BMI)[4].

Excess energy intake, physical inactivity, and sedentary lifestyles are prevalent in Chinese schoolchildren[5], but associations of ERBs with childhood obesity or related cardiometabolic outcomes have seldom been studied in China. To identify targets for modifiable behaviors, such as diet, physical activity (PA), and sedentary behaviors, and to establish working priorities for controlling childhood obesity in China, we analyzed data from a cohort of 197 overweight or obese Chinese schoolchildren in 2013[6]. We used the Group of China Obesity Task Force criteria for overweight (85th percentile ≤BMI< 95th percentile) and obesity (BMI ≥95th percentile) based on age and gender[6]. This study was approved by the Medical Research Ethics Committee of Peking University Health Science Center IRB (0000105212062). We examined the association of eating behaviors, leisure-time PA, and screen time with obesity and the following cardiometabolic variables at baseline: blood pressure (BP), systolic blood pressure (SBP), diastolic blood pressure (DBP), waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), blood glucose (GLU), total cholesterol (TC), triglycerides (TG), low-density lipoprotein (LDL-C), and high-density lipoprotein (HDL-C) (Table 1 and Table 2). We used baseline ERB data to predict BMI and body fat percentage one year later (Table 3). A modified Dietary Approach to Stop Hypertension Diet score (DASH score) was created based on a previous publication and was used as a composite eating behavior index to reflect the overall quality of eating behaviors[7].

Our sample consisted of 114 boys and 83 girls

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with a mean age of 10.9±2.2 years (range: 8-14 years). Participants had a mean BMI of 24.7±3.7 kg/m^2 and fat percentage of 34.2%±8.3%, as measured using a BIA body composition analyzer (MC-980MA, Tanita Co., Guangzhou, China).

The baseline DASH score was low: 2.7%±0.9 out of a total possible score of 7. None of the participants met the food quality standard of the DASH diet (i.e. a score of 7). Moreover, healthy eating behaviors that may reduce energy intake (e.g., consumption of fruits and vegetables, milk, and whole grains/seeds) were reported by only 20%-40% of overweight children. In contrast, behaviors that may lead to excessive energy intake were common among overweight children. For example, 50% of overweight children reported drinking sugarsweetened beverages (SSBs) ≥1 time/week, 30% reported eating out, and 30% reported skipping breakfast. These findings are consistent with many previous studies with large sample sizes[8].

In terms of energy expenditure, 77.5% of children reported engaging in vigorous PA at least 3 days/week, while 33.7% reported engaging in leisure time moderate-to-vigorous PA at least 5 days/week[9]. The recommended total screen time for children is less than 60 min per day[10], and this standard was met by only 24% of our study population (Table 1).

Table 1. Energy-balance-related Behaviors in Overweight and Obese Children

Behaviors (Recommendation)	Cross-sectional Study Baseline (*n*=197)		One-year follow-up Study Baseline (*n*=141)	
	n (%)	Median (QI) or Mean±SD	*n* (%)	Median (QI) or Mean±SD
Eating behaviors				
Fruits (≥2 servings/d)	45 (23.8)	4-6/week (1-3/week, 1/d)	37 (22.4)	4-6/ week (1-3/week, 1/d)
Vegetables(≥2 servings/d)	87 (46.0)	1/day (4-6/week, 2/d)	69 (46.7)	1/day (4-6/week, 2/d)
Milk (≥2 cups/d)	23 (12.2)	4-6/week (1-3/week, 1/d)	19 (9.0)	4-6/week (1-3/week, 1/d)
Meat (≤1 serving/d)	168 (87.6)	4-6/week (1-3/week, 1/d)	125 (92.6)	4-6/week (1-3/week, 1/d)
Nuts (≥1 handful/d)	38 (20.0)	1-3/week (0, 4-6/week)	29 (17)	1-3/week (0, 4-6/week)
Whole grains (≥ 1 time/d)	50 (26.3)	1-3/week (1-3/week, 1/d)	37 (23)	1-3/week (1-3/week, 4-6/week)
Fries (≤3 times/week)	153 (80.5)	1-3/week (0, 1-3/week)	114 (84.4)	1-3/week (0, 1-3/week)
Sugared foods (≤3 times/week)	112 (59.9)	1-3/week (1-3/week, 4-6/week)	83 (61.9)	1-3/week (1-3/week, 4-6/week)
Fast foods (≤3 times/month)	181 (96.8)	0 (0, 2-3/month)	130 (97.7)	0 (0, 1/month)
SSB (≤1 time/week)	94 (51.6)	1/week (<1/week, 2-4/week)	75 (57.3)	1/week (<1/week, 2-4/week)
Skipping breakfast (<7 times/week)	141 (70.1)	7/week (6/week, 7/week)	104 (72.4)	7/week (6/week, 7/week)
Eating out (≤1 time/d)	180 (90.5)	3/week (1/week, 7/week)	123 (93.2)	3/week (1/week, 7/week)
Family meals (≥2 times/d)	70 (37.5)	7/week (6/week, 15/week)	57 (36.4)	7/week (5/week, 15/week)
Physical activity (d/week)				
M-V physical activity (≥5)	63 (33.7)	3.5 (2, 5)	54 (35.1)	3.5 (2, 5)
Vigorous physical activity (≥3)	145 (77.5)	4 (3, 6)	109 (75.9)	4 (3, 6)
Muscle strengthening (≥3)	88 (46.8)	2 (1, 4)	66 (44.0)	2 (1, 4)
Bone strengthening (≥3)	109 (58.0)	3 (1, 5)	80 (54.5)	3 (1, 5)
DASH Score (quartiles)	0 (0.0)	2.7±0.9	0 (0.0)	2.7±0.9
Sedentary behaviors (≤60 min/d)				
TV viewing	107 (54.3)	72.6±55.0	67 (50.8)	76.4±55.4
Other screen	126 (64)	59.5±58.4	88 (67.7)	52.8±51.4
Total screen time	46 (24)	130±90.6	33 (25.8)	125.6±85.1

Note. M-V physical activity, Moderate-to-vigorous physical activity; QI: Quartiles interval.

Among all eating behaviors that were measured, only meat consumption was positively associated with TC (partial r=0.21, P<0.05) and LDL-C (partial r=0.22, P<0.05) at baseline. Stronger associations were found between energy expenditure (e.g., leisure time PA and screen time) and obesity. In fact, BMI, fat percentage, and HC were negatively correlated with PA (partial r: -0.162 to -0.316, P<0.05 for aerobic and anaerobic activities) and positively correlated with sedentary behaviors (partial r=0.170, P<0.05 for total screen time). Fat percentage and WHR were moderately and negatively correlated with participation in team sports in children younger than 4th grade (partial r: -0.280 to -0.316, P<0.05). These findings suggest that reducing sedentary behaviors and increasing PA may prevent excessive weight gain in Chinese schoolchildren, and thus should be given high priority.

Among the 141 children that remained at follow-up, BMI increased by 0.88±1.79 kg/m^2 and fat percentage increased by 0.59±5.58 percent points. In a multiple linear regression model, individual and composite indicators of eating behaviors (e.g. DASH score), PA (days/week), and screen time (minutes/day) were entered or removed from the equation as explanatory variables using the Enter method, while simultaneously adjusting for the following covariates that were significant at baseline: (for one-year later BMI: baseline age, baseline BMI, DASH score, and other screen time; for one-year later fat percentage: baseline fat percentage, eating out, DASH score, and PA). We found that baseline adiposity (measured by either BMI or fat percentage) was the strongest predictor of adiposity one year later (BMI or fat percentage), followed by age (only for BMI) and eating out (only for fat percentage). DASH score was less strongly associated with BMI. Our regression equations explained 78.5% and 51.6% of the variance of BMI and fat percentage at follow-up, respectively (Table 3).

Table 2. Baseline/Follow-up Anthropometric and Cardiometabolic Variables (mean±SD)

Variables	Cross-sectional Baseline (n=197)	One Year Follow-up	
		Baseline (n=141)	Follow-up (n=141)
Height (cm)	154.0±13.2	151.9±13.6	157.5±12.3
Weight (kg)	59.8±16.5	58.3±17.1	64.3±15.8
Fat percentage (%)	34.2±8.3	34.6±7.6	35.2±8.1
BMI (kg/m^2)	24.7±3.7	24.7±3.6	25.6±3.6
WC (cm)	82.9±10.3		
HC (cm)	93.4±9.8		
WHR (cm/cm)	0.9±0.1		
SBP (mmHg)	110.7±12.2		
DBP (mmHg)	66.9±8.9		
Glu (mmol/L)	5.1±0.4		
TC (mmol/L)	3.7±0.7		
TG (mmol/L)	1.2±1.1		
HDL-C (mmol/L)	1.1±0.3		
LDL-C (mmol/L)	1.8±0.5		

Table 3. Use of Baseline Energy-balance-related Behaviors to Predict Change in BMI and Fat Percentage Over One Year (n=141)

Variables	Correlation Coefficient (r)	Coefficient (β)	95% CI	P-value
One-year Follow-up BMI (kg/m^2)				
Age (y)	-0.215	-0.134	-0.412 to -0.039	0.019
Baseline BMI (kg/m^2)	0.845	0.969	0.866 to 1.092	0.000
DASH Score (quartiles)	-0.180	-0.086	-0.734 to 0.000	0.050
Other screen use (mins/d)	-0.157	-0.080	-0.012 to 0.001	0.087
One-year Follow-up fat percentage				
Baseline fat percentage (%)	0.688	0.590	0.870 to 0.693	0.000
Eating out (times/w)	0.181	0.004	0.516 to 0.197	0.047
PA (days/week)	-0.107	-0.707	0.182 to -0.080	0.245
DASH Score (quartiles)	-0.126	-1.941	0.345 to -0.225	0.169

In this study, DASH score was used as an index of healthy eating to capture the overall effects of eating behaviors in Chinese children. Our results showed that lower DASH scores could be used to predict excess body fat gain and demonstrated their usefulness as a composite index of overall eating patterns in children. In addition, we showed that non-TV screen time plays a role in promoting adiposity.

Although many previous studies have reported the prevalence of individual ERBs in healthy children, few studies concurrently considered the three components of energy balance, which may be important in predicting excess body fat gain and thus setting intervention targets for obesity control. In the present study, we examined the relative contributions of energy intake and expenditure to the development of childhood obesity, both cross-sectionally and prospectively. Overall, our results suggest that ERBs are associated with changes in adiposity in Chinese schoolchildren over time, and that behaviors relating to energy expenditure should be intervention priorities.

Our study has several limitations and thus our findings should be interpreted with caution. First, our study was conducted in overweight Chinese schoolchildren and cannot be generalized to other populations. Second, the small variability in some variables and possible systematic under-reporting of some foods may have affected the associations between exposures and outcomes. Third, we did not adjust for total energy intake, which may be an important confounder. Fourth, the use of a self-administered questionnaire may have introduced inaccuracies in our assessment of eating and PA behaviors. Finally, our analyses were based on cross-sectional and short-term longitudinal data.

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CONFLICTS

The authors declare that they have no conflict of interest.

AUTHORS' CONTRIBUTIONS

LI Liu Bai, WANG Ling, LI jing Jing, and YANG Miao developed the measuring tools and participated in the collection and analysis of data. LI Liu Bai, MA Jun, WANG Nan, and WU Xu Long wrote the first draft of this paper. MA Jun provided advice on recruitment strategies, as well as school and parental engagement activities. All authors contributed to the final version of the paper. All authors read and approved the final manuscript.

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