

Factors associated with overweight status, obesity, and sedentary behavior in elementary and junior high school students

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ABSTRACT. Background: Sedentary behavior increases the risks of obesity and cardiovascular disease in adults, but these relationships are uncertain in elementary and junior high school students. We investigated whether sedentary behavior is related to overweight status and obesity in high-risk children with lifestyle diseases. **Method:** A cross-sectional study was performed in 115 children and primary caregivers who attended a lecture for preventing child lifestyle diseases in Ibaraki prefecture, Japan. The main outcome measure was excess weight (percent overweight). Factors associated with excess weight in children were evaluated using multiple regression analysis. Basic physical and demographic characteristics, biochemical data (total cholesterol [TC], low and high density lipoprotein cholesterol [LDL-C and HDL-C], alanine aminotransferase [ALT]), blood pressure, child and parental sedentary time, parental BMI, and family environment were evaluated. **Results:** In total, 107 children were eligible for participation in the study. Excess weight in these children was 28.6 ± 18.4 . Sedentary time was 337.2 ± 122.5 min/day in children and 347.0 ± 196.2 min/day in parents. Multiple regression analysis revealed that children's sedentary behavior ($\beta = 0.02$, (95% CI: 0.00 to 0.04)) and HDL-C ($\beta = -0.59$, (95% CI: -0.81 to -0.38)) as independent predictors of children's excess weight. **Conclusion:** Study findings suggest that decreasing children's sedentary behavior in addition to greater physical activity is important for the prevention of overweight status and obesity in high-risk children with lifestyle diseases. Reduction of sedentary time, and engaging in regular exercise are all important for proper weight maintenance in children.

Key words: Sedentary behavior, Children's overweight, Children's Obesity, Children's percent overweight, Elementary and Junior high school students

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Childhood obesity is a major global health problem¹. The prevalence of overweight and obesity (Ow/Ob) among Japanese children more than doubled from 1970 to 2000, and recent estimates suggest that approximately 10% of

Japanese children are currently Ow/Ob². Overweight children are 4.5 times more likely to have elevated systolic blood pressure (SBP) and 2.4 times more likely to have elevated diastolic blood pressure (DBP) than normal or underweight children³. These children are also at increased risks for heart disease and various chronic diseases later in life (lifestyle diseases) such as hyperlipidemia, hyperinsulinemia, hypertension, and type 2 diabetes^{4,5}.

Family environment greatly influence Ow/Ob in children. Previous studies have reported that parental body mass index (BMI)⁶, single parent status⁶, maternal employment status^{7,8}, and parental physical activity levels⁹ influ-

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enced childhood Ow/Ob. Moreover, physical inactivity has been shown to have a major effect on Ow/Ob rates worldwide¹⁰. Increasing physical activity is obviously critical for the prevention of Ow/Ob. Physical activity level in daily living is classified into three levels, sedentary, light, and moderate, and exercise for prevention of Ow/Ob has been shown to increase moderate physical activity. However, only 5% of daily living is spent in moderate physical activity, while sedentary time accounts for 60%¹¹. To prevent Ow/Ob, it is thus also important to reduce sedentary time. Indeed, sedentary behavior is related to Ow/Ob independent of physical activity¹¹.

Sedentary time influences Ow/Ob in adults, but the relationship between sedentary time and Ow/Ob has not been evaluated in schoolchildren. Shorter sedentary time is related to low BMI¹², but factors associated with sedentary time in Ow/Ob schoolchildren have not yet been clarified. Here, we investigated factors associated with sedentary time and their relationships with Ow/Ob in schoolchildren.

Methods

Participants

The study participants were aged 9-13 years children and their caregivers who attended a lecture on childhood lifestyle disease prevention in Ibaraki prefecture, Japan. This lecture is held by pediatricians and physicians for caregivers of children identified as outliers during screening for the prevention of childhood lifestyle diseases in each municipality.

This cross-sectional study was performed from April to September 2015. It was conducted in accordance with the tenets of the Declaration of Helsinki and was approved by the Ethics Committee of the University of Tsukuba (approval number: 949).

Measures

We first provided a verbal explanation of the study to caregivers. We then distributed a self-administered questionnaire to the parent who attended the lecture on lifestyle disease prevention for children, and we collected it immediately. The questionnaire included items about the children's physical and demographic characteristics, daily lifestyle, and family environment. Only those caregivers who agreed to participate in the study anonymously returned the questionnaire. We considered return of the filled-in questionnaire as informed consent.

School physical examination

In Ibaraki prefecture, school physical examinations aimed at prevention of lifestyle-related diseases in children are performed at 9 or 10 years and 12 or 13 years of age. Height, weight, biochemical data (total cholesterol [TC], low and high density lipoprotein cholesterol [LDL-C and

HDL-C], and alanine transaminase [ALT]), and blood pressure were measured. These examination results were published directly and transferred to the health management systems of schools and to caregivers. If an abnormal value was found, the child was recommended to attend the lecture on childhood lifestyle disease prevention.

Definitions of Obesity and Metabolic Syndrome

The study assessed the prevalence of childhood lifestyle disease risk factors according to the Japan Association of Health Services. The severity of obesity in children was determined according to the relative weight (RW), which is expressed as a percentage of the standard body weight for age, height, and sex, while that of parents/caregivers was based on BMI using the World Health Organization (WHO) criteria. Standard body weight was determined using Murata's nomogram, which is a weight-for-height by sex and age chart for Japanese children derived from nationwide surveys¹³. Abnormally high weight was defined as 20% or more above the normal values (defined below). We also used cutoffs of 135 mmHg for abnormal SBP and 80 mmHg for abnormal DBP. Standard cutoff values for abnormal blood lipids were ≥ 220 mg/dL for TC, <40 mg/dL for HDL-C, and ≥ 140 mg/dL for LDL-C.

Children's characteristics and anthropometric measurements

Children's physical and demographic characteristics included age and sex. Body weight (recorded in kilograms to one decimal place) and height (recorded to the nearest millimeter) were measured at each school. The same examination protocol was used throughout the study period to ensure uniformity and precision of assessment.

Standing height and weight were measured, and BMI and excess weight (%) were calculated. BMI calculated as body weight (kg) divided by the height squared (m^2). The excess weight was determined on the basis of the Japanese standard body weight for height by age and sex using the following formula: $[(\text{actual body weight} - \text{standard weight}) / \text{standard weight}] \times 100\%$. According to excess weight criteria, children with excess weight $\leq -20\%$ were classified as underweight, and those excess weight $\geq +20\%$ were classified as overweight. In addition, excess weight 20% to 29% was classified as mild overweight, excess weight 30% to 49% as moderate overweight, and excess weight $\geq +50\%$ as highly overweight¹³.

Children's daily lifestyle

Children's daily lifestyle can be graded according to sedentary behavior, physical activity, and sleeping habits. Sedentary behavior was examined by the Sedentary Behavior Questionnaire (SBQ), a self-report measure of time spent in sedentary behavior during a typical week. The SBQ assesses nine types of sedentary activities: watching

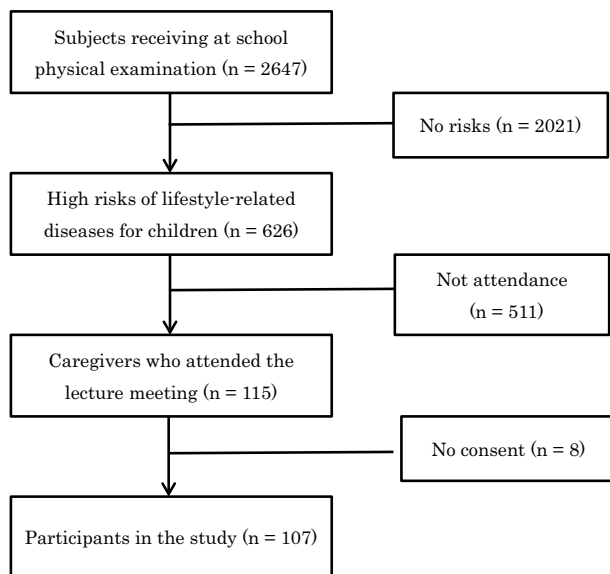


Figure 1. Flow diagram showing the steps to the final study sample

television, playing computer/video games, sitting while listening to music, sitting and talking on the phone, doing paperwork or office work, sitting and reading, playing a musical instrument, doing arts and crafts, and sitting and driving/riding in a car, bus, or train on weekdays and weekends¹⁴). Physical activity in school included method of transportation (e.g., walking, bicycling) and club activities. Club activities were examined by name, and classified as exercise or cultural activities. Sleeping habit was defined as nighttime sleep duration per day.

Family environment

Family environmental factors included parental status, parental age, maternal height and weight, maternal employment status, and family economic status. Parental status was dichotomized as one or two parents. Parental height and weight were determined based on self-report and BMI calculated as body weight (kg) divided by the height squared (m²).

Family economic status was determined based on the answers to “How do you consider your economic status?” (enough, well, I can buy necessary things, I’m not troubled to eat, it is all one could do to eat). Maternal employment status was dichotomized as employed (full-time, part-time, self-employed) or unemployed (housewife).

Statistical analysis

Multiple linear regressions with excess weight as the dependent variables were computed to show the effect of the children’s sedentary time. On an a priori basis, potential confounders, namely sex, parental BMI, and HDL-C cholesterol were included in model 1. Moreover, univariate correlation analyses were performed to examine the significance and strength of associations of excess weight with

physical, clinical, and family environment variables. Variables with $p < 0.3$ were included in all possible regressions. These variables that were significant in the univariate analyses are listed in Table 2. A previous study found linear associations between sedentary time and low HDL-C¹⁵). Although total, HDL, and LDL-C were all significant, we included only the HDL-C to model 2. Thus, we included children’s sedentary time, parental BMI, HDL-C, and sleeping duration per day in model 2. Although parental sedentary time was generally considered to be a potential confounder of children’s excess weight¹⁶), it was excluded from models 1 and 2 because of its multicollinearity with children’s sedentary time. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were used as measures of effects and statistical significance. All analyses were performed using SPSS version 22.0 for Windows. A p value < 0.05 was considered statistically significant and p values were based on 2-sided tests.

Results

Participants

In total, 2647 children (aged 9-13 years) attended school physical examinations in three cities of Ibaraki prefecture. After the examination, 626 children were determined to have an abnormal value or to be at high risk for obesity (Fig. 1). If an abnormal value was found, the subject was recommended to attend the lecture on childhood lifestyle disease prevention. This lecture is held by pediatricians and physicians for caregivers of children identified as outliers during screening for the prevention of childhood lifestyle diseases in each municipality. The present study was conducted on 115 caregivers who attended the lecture, of which 107 were included in the analyses (recovery rate of 91.5%). The various physical and clinical characteristics of the children and variables of family environment are summarized in Table 1. The average (\pm SD) excess weight in children was $28.6\% \pm 18.4\%$. Average sedentary time was 337.2 ± 122.5 /day in children and 347.0 ± 196.2 /day in parents (Table 1).

Table 2 presents the association between each variable and excess weight. HDL-C ($r = -0.50$, $p < 0.01$), Paternal BMI ($r = 0.29$, $p = 0.03$), children’s sedentary time ($r = 0.12$, $p = 0.28$) and sleeping duration per day ($r = 0.52$, $p = 0.04$) were significantly associated with children’s excess weight.

Table 3 presents the results of multiple regression analysis, which revealed children’s sedentary time ((Model 1; $\beta = 0.02$, (95%CI: 0.00 to 0.04) Model 2; $\beta = 0.02$, (95%CI: 0.01 to 0.04)) and HDL-C ((Model 1; $\beta = -0.59$, (95%CI: -0.81 to -0.38) Model 2; $\beta = -0.56$, (95%CI: -0.80 to -0.38)) as independent predictors of children’s excess weight.

Table 1. Study participants' characteristics (*N* = 107)

	n (%)	Mean ± SD
Sex		
Boys	54 (50.5)	
Girls	53 (49.5)	
Age (years)	107	10.5 ± 1.4
Height (cm)	107	139.6 ± 10.6
Weight (kg)	107	44.5 ± 11.8
BMI (kg/m ²)	107	22.5 ± 3.6
Excess weight (%)		
Nomal	21 (19.6)	
Excess weight 20 to 30%	33 (30.8)	
Excess weight 30 to 50%	43 (40.2)	
Excess weight 50% over	10 (9.4)	
Biochemical data		
Systolic blood pressure (mmHg)	107	113.1 ± 8.7
Diastolic blood pressure (mmHg)	107	59.6 ± 6.7
Total cholesterol (mg/dl)	107	192.0 ± 38.6
HDL-C (mg/dl)	107	59.4 ± 17.0
LDL-C (mg/dl)	107	117.9 ± 34.2
ALT (U/L)	107	23.2 ± 18.7
Sedentary Behavior/day (min)		
Children's sedentary time		
Normal	21	315.0 ± 142.9
Excess weight 20 to 30%	33	324.9 ± 151.3
Excess weight 30 to 50%	43	325.8 ± 162.0
Excess weight 50% over	10	466.9 ± 420.1
Parental sedentary time	107	347.0 ± 196.2
Physical Acvtivity Habits		
The way of transporting for school		
By walk	74 (69.2)	
By bicycle	29 (27.1)	
By car	4 (3.7)	
Club Activites		
Exercise	34 (31.8)	
Culture	38 (35.5)	
Lifestyle Habits		
Sleeping duration per day		
4-6 hours	3 (3.4)	
6-8 hours	52 (59.8)	
8-10 hours	31 (35.6)	
More than 10 hours	1 (1.1)	

Discussion

The purpose of the present study was to clarify the influence of sedentary behavior (duration) on excess weight (percent overweight) of high-risk children with lifestyle diseases. Indeed, children's sedentary time was significantly associated with children's excess weight.

Excessive sedentary behavior in adults is associated with increased risks for several chronic conditions and early mortality¹⁷⁾, and an estimated one half of all obese children

will become obese adults. Adult lifestyle cannot be changed easily, so it is important to establish a healthy lifestyle during childhood. In schoolchildren, however, it is still debated whether sedentary behavior is associated with excess body weight (Ow/Ob). Leblanc et al reported that short sitting times were associated with low excess weight¹²⁾. On the other hand, Stamatakis et al reported that long sitting times were not associated with childhood obesity¹⁸⁾. In the present study, child sedentary time was associated with excess weight.

Table 1. Study participants' characteristics ($N = 107$) (continued)

	n (%)	Mean \pm SD
Family environments		
Parental status		
Two parents	102 (95.3)	
One parent	5 (4.7)	
Parental age (years)	96	41.6 \pm 4.9
Parental BMI (kg/m ²)	65	23.7 \pm 4.9
Maternal employment status		
Housewife	17 (17.9)	
Employment	85 (82.1)	
Employment status		
Full-time	27 (25.2)	
Part-time	47 (43.9)	
Self-employed	11 (10.3)	
Economic status		
Comfortable	5 (10.3)	
I can buy necessary things	64 (59.8)	
Enough to eat	26 (24.3)	
Difficult to eat properly	8 (7.5)	

HDL-C: high-density lipoprotein cholesterol, LDL-C: low-density lipoprotein cholesterol, ALT: alanine aminotransferase

Table 2. Correlations between Children's excess weight (%) and clinical variables

	correlation	<i>p</i> -value
Male sex	0.02	0.84
HDL-C	-0.50	<0.01
Parental BMI (n = 65)	0.29	0.03
Child's sedentary time	0.12	0.28
Parental sedentary time	0.15	0.28
Sleeping duration per day	0.52	0.04

HDL-C: high-density lipoprotein cholesterol
Pearson's correlation coefficient

Table 3. Multiple regression analysis of Children's excess weight (%) and Children's sedentary time

	Model 1			Model 2		
	β	(95% CI)	<i>p</i> -value	β	(95% CI)	<i>p</i> -value
Children's sedentary time	0.02	0.00 to 0.04	0.05	0.02	0.01 to 0.04	0.05
HDL-C	-0.59	-0.81 to -0.38	0.01	-0.56	-0.80 to -0.38	0.01

* CI: confidence interval, HDL-C: high-density lipoprotein cholesterol.

[Model 1] $R^2 = 0.31$, $p < 0.01$ [Model 2] $R^2 = 0.31$, $p < 0.01$

Adjusted variables include: [Model 1] Sex, Children's sedentary time, HDL-C, Parental BMI. [Model 2] Sex, Children's sedentary time, HDL-C, Sleeping duration per day.

Furthermore, we found that HDL-C and sedentary time were independently related to excess weight in children, a finding consistent with a previous study. In adults and children, HDL-C is inversely correlated with obesity, and a low HDL-C level predicts obesity¹⁵⁾. Low HDL-C

level is also a major risk factor for cardiovascular disease, particularly, in cases of severe obesity. In obese schoolchildren as well, HDL-C levels tend to be low, and an elevated risk of cardiovascular disease has been reported¹⁹⁾. Regular exercise is known to reduce the risks of metabolic and car-

diovascular diseases. On the contrary, a sedentary lifestyle reduces systemic lipid oxidation and the expression of fatty acid transporter in skeletal muscle²⁰). Therefore, management of weight and lipids, reduction of sedentary time, and engaging in regular exercise are important for healthy weight maintenance.

In addition, the proportions of subjects who reported “watching TV”, “playing games”, and “using a mobile phone” during sedentary times were higher than in subjects reporting other activities (data not shown). Previous studies have reported consistent positive associations between longer TV watching time and childhood Ow/Ob^{21,22}). Reduced steps have been reported among elementary and junior high school students²³), and mobile phone use is common, especially with pre-teens and teens, so total screen time tends to be long²⁴). In addition, outdoor play has been reduced due to safety concerns²⁵). As a consequence, sedentary time is likely to increase. Therefore, sedentary behavior should be controlled by caregivers during childhood, for example by limiting overall time spent using a mobile phone and prohibiting children from sleeping with a mobile phone.

Limitation

Our study demonstrates the influence of sedentary behavior in childhood on Ow/Ob. Nevertheless, our study had some limitations. First, measurements were based on caregivers’ reports, so sedentary behavior may be underreported. Second, this research concerned caregivers who attended a lecture on childhood lifestyle disease prevention. Therefore, subjects had a greater proportion of Ow/Ob children, so larger samples are required to generalize these findings. Third, since visceral fat accumulation influences the health effects of obesity, it is important to measure waist circumference in future studies. A previous study found an association between sedentary time and waist to height ratio²⁶), but we do not measure the waist circumference. This study cohort may also contain cases with secondary causes of obesity. Finally, we did not consider diet (e. g., fat, carbohydrate, protein contents) and intensity of physical activity. Children’s weight and height were measured at each school, while biochemical data were measured precisely under laboratory conditions, which may have led to underestimations and obscured real associations. Further studies including more detailed and objective measurements of both children’s lifestyle factors and family environment are essential.

Conclusion

Our findings suggest that sedentary behavior duration significantly increases Ow/Ob in schoolchildren. These findings indicate the importance not only of increasing

physical activity but also of reducing sedentary behavior (time watching TV, playing games, using smartphones) to prevent childhood obesity. Reduction of sedentary time, and engaging in regular exercise are all important for proper weight maintenance in children.

Conflict of Interest: There is no conflict of interest to disclose

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