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Meta-analytical Summary to Identify Obesity Risks in Schoolchildren

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Abstract The aim of the present study was to identify obesity risks in the lifestyles of schoolchildren. The subjects included 478 boys and 438 girls aged from 6 to 15 years. Obesity, breakfast intake, sleep time and exercise frequency were subjected to the logistic regression analysis and the meta-analytical summary by sex and age. The mean body mass index (BMI) increased with age for all subjects except 7-year-old boys and 15-year-old girls. Breakfast intake and sleep time decreased with age. Exercise frequency increased with age. We conducted a meta-analytical summary of the logistic regression analysis, and found a significant correlation between obesity and exercise frequency in 13-15-year-old boys.
One results indicated that the decrease in the exercise frequency is the risk of obesity for 13-15-year-old boys. The lifestyles of schoolchildren change with age, and distributions of lifestyle-related variables are not constant. For such an inconsistent target, the meta-analytical summary for all subjects based on a multiple logistic regression analysis for each group is useful.

Key Words: meta-analytical summary, obesity, exercise frequency, schoolchildren, lifestyle

Introduction

Since the promulgation of "Healthy Japan 21", health promotion measures in Japan have placed emphasis on establishing healthy lifestyle habits and preventing lifestyle-related diseases. The aim is to see how much the incidences can be reduced of the so-called lifestyle-related diseases, including obesity, diabetes, hypertension, hyperlipidemia, heart disease, stroke, and cancer. Obesity and diabetes are basic risk factors for the development of chronic diseases, so it is important that they be prevented in the early stages.

Muramatsu et al. observed 309 boys and 335 girls at birth, 3, 6, 11, 14, and 17 years, and revealed that obese, medium or lean infants at age 3 tend to become obese, medium or lean adolescents at age 17 respectively, among the boys. They also wrote that, among the girls, a statistically significant relationship existed between the obese group at 17 and at the other ages, including at birth. They recommended that prevention of obesity should start as early as possible, at least from 3 years of age.[1)]

Boreham et al. suggested that there is a biological carryover effect into adulthood, whereby improved adult health status results from childhood physical activity. They stressed that childhood obesity may be a precursor for a range of adverse health effects in adulthood.[2)] In today's age of overeating, obesity prevention measures are required throughout life.

It is difficult for children by themselves to establish living habits, as they are influenced by the lifestyles of their parents. Burke et al.

reported that the BMI of both sons and daughters was predicted additively by the BMI of their fathers and mothers, with independent contributions from variables reflecting health behaviors, particularly physical fitness and alcohol intake.[3)]

On the other hand, in longitudinal surveys and studies of children in their period of marked growth in elementary and middle school, the normal values of physical measurements differ with the children's ages. Sleep and other factors that make up the daily time schedule also differ greatly. Therefore, children from elementary to middle school cannot be pooled together in a single group and analyzed en masse. Blair et al. reported that meta-analysis, when used appropriately, can enhance understanding of association between sources of exposure and their effects that may not be apparent from individual examination of epidemiological studies.[4)]

In the current study, because there were too few subjects to make a definite conclusion in the risk identification for obesity, we grouped the children into 3 levels, by age. Then we conducted a meta-analytical summary. The relation between obesity and lifestyle factors such as exercise and sleep was analyzed using appropriate standards for each age group. The results were summarized meta-analytically, and an attempt was made to identify risk factors by age group.

Subjects and Methods

1. Survey Subjects

The subjects of the survey were all children aged 6-15 years (boys 536, girls 527) residing in "Town A" in Hiroshima Prefecture. Responses were received from a total of 916 children, 478 boys and 438 girls, for a valid response rate of 86.2%.

The response numbers by age group for boys were 153 in the 6-9 year old group, 177 in the 10-12 year old group, and 148 in the 13-15 year old group. For girls they were 168 in the 6-9 year old group, 147 in the 10-12 year old group, and 123 in the 13-15 year old group.

2. Methods

The survey was conducted in November 2002. Normally, at this time of the year, there are relatively few infectious diseases, and very few school events such as school festivals or athletic meets, so it is easy to gain an understanding of the children's regular daily lives. The 9 question items on the survey were age, sex, height, weight, breakfast intake, exercise frequency, exercise time, bedtime, and wake up time. Body mass index (BMI=Weight (kg)/(Height (m))^2) was used as the main indicator of obesity in this study.

Using the statistical package HALBAU for Windows, ver. 5.4, we calculated the means and standard deviations for BMI, exercise frequency, sleep time by sex and age groups. The subjects were classified in two levels by sex and 10 levels by age, for a total of 20 groups. Mean BMI was calculated for each group. With this value as reference, the children were classified into three obesity groups: non-obese (BMI $<+10\%$ of mean), mildly obese (BMI $+10\%$ to $+<20\%$ of mean), and obese (BMI $\geqq +20\%$ of mean). Breakfast intake was classified into four categories of every day, 3 or more times/ week, rarely 3 times/ week, and skipped.

Sleep time was calculated from bedtime to waking time. Following the classification method for sleep time in the 2001 Survey of Physical Strength and Exercise Capacity by the Ministry of Education, Culture, Sports, Science and Technology, sleep time was grouped as less than 6 hours, 6-8 hours, and more than 8 hours.[5)] However, since there were few subjects who slept less than 6 hours, we adopted the two groups: less than 8 hours (short sleep time group) and 8 hours or more (long sleep time group).

Four levels were established for exercise frequency: every day, 3 or more times/week, rarely 3 times/week, and never. Exercise time was expressed in units of minutes.

In performing the multiple logistic regression analysis, "non-obese and mildly obese cases" were taken as 0, and "obese cases" were taken as 1. This is a binary variable as the dependent variable. As the explanatory variables, "breakfast intake: everyday", "exercise frequency: everyday and 3 or more times/week", and "long time sleepers" were taken as 0, and cases other than these cases were taken as 1. The analysis was conducted with a binary variable, obese or not, as the dependant variable, and breakfast intake, exercise frequency, and

sleep time as explanatory variables. Software developed by Masui was used in the meta-analytical summary.[6] Prentice and Thomas developed a general variance-based method for meta-analysis where the effect measures are ratio measures that require only information on each study's estimate of relative risk and its 95% confidence interval.[7]

The summary measure of effect, RR_s, is calculated as follows.

$\ln RR_s = \text{sum } (w_i \times \ln RR_i)/\text{sum } w_i$

where $w_i = 1/\text{variance } RR_i$

The RR_i are estimates of relative risk and may have been measured as odds ratios, rate ratios, or risk ratios. The formula for estimating variance from the 95% confidence interval given by Prentice and Thomas (1986) is

$$\text{Variance } RR_i = [\ln (RR_i/RR_l)/ 1.96]^2$$

where RR_i is the estimate of the relative risk in the ith (numerical value of an i joint) study.

A 95% confidence limit for the estimated relative risk is calculated as

$$95\%\ CI = e^{\ln RRs \pm 1.96 \times \sqrt{\text{variances}}}$$

$$\text{variances} = 1 /(\text{sum weight}_i)^{8)}$$

The factors that contributed to obesity were analyzed in each of these three groups: 6-9-year-olds, 10-12-year-olds, and 13-15-year-olds. We attempted to identify the risks for obesity in children 6 though 15 years of age using the above-mentioned meta-analysis. Three types of lifestyle factors were used: breakfast intake, sleep time, and exercise frequency.

Results

Table 1 shows the mean, SD, minimum, and maximum for BMI, sleep time, and exercise time by sex and age. The mean BMI increased with age for all except 7 year-old boys and 15 year-old girls. The maximum BMI exceeded

Table 1 Mean, SD, minimum, and maximum values for BMI, sleep time, and exercise time by sex and age.

		boys					girls				
	Age	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max
BMI					n=446					n=405	
(kg/m^2)	6	24	16.3	2.70	12.8	24.1	19	15.3	1.41	12.2	17.4
	7	32	15.9	2.05	13.4	23.9	47	15.8	2.06	13.0	24.5
	8	39	16.5	2.31	12.9	23.6	42	16.3	2.48	13.2	25.3
	9	40	17.1	2.01	14.1	23.1	40	17.6	3.24	13.7	26.6
	10	49	17.4	2.44	13.9	24.3	41	17.9	2.87	13.2	24.7
	11	64	18.7	2.88	13.4	26.4	50	18.8	3.48	14.2	27.6
	12	54	18.8	3.17	14.3	29.3	51	18.8	2.72	14.5	26.2
	13	50	19.5	3.67	14.8	32.1	43	19.2	3.65	13.9	35.5
	14	54	20.0	2.95	15.8	33.6	51	20.6	2.83	15.8	29.4
	15	40	20.4	2.48	16.6	27.7	21	19.7	1.95	16.3	23.2
sleep time					n=469					n=324	
(hour)	6	27	9.3	0.55	8.0	10.5	22	9.4	0.67	8.0	11.0
	7	36	9.3	0.58	8.0	10.5	56	9.3	0.42	8.5	10.0
	8	43	9.1	0.57	7.5	10.0	45	9.2	0.57	8.0	11.0
	9	44	9.0	0.53	8.0	10.0	45	9.0	0.50	8.0	10.0
	10	52	8.9	0.54	8.0	10.0	42	8.7	0.46	7.9	9.5
	11	68	8.8	0.72	6.0	11.0	51	8.6	0.56	7.0	10.0
	12	53	8.4	0.60	7.0	9.3	51	8.3	0.61	6.5	9.5
	13	52	8.1	0.58	7.0	9.5	46	7.9	0.81	5.7	9.3
	14	54	7.9	0.82	6.0	10.0	54	7.5	0.71	6.0	9.0
	15	40	8.7	0.67	5.9	9.5	22	7.6	0.64	6.0	8.5
exercise time					n=266					n=159	
(minute)	6	13	80.8	29.73	30	120	6	75.0	33.54	30.0	120.0
	7	12	74.3	38.13	30	180	16	65.6	33.54	10.0	120.0
	8	18	87.2	61.45	10	210	14	72.9	31.49	30.0	120.0
	9	22	132.6	69.23	30	300	13	74.6	29.25	30.0	120.0
	10	28	127.3	80.65	25	360	12	76.7	42.49	20.0	180.0
	11	37	123.9	70.68	10	300	12	115.0	57.23	60.0	240.0
	12	40	130.5	55.94	60	300	26	108.1	49.46	30.0	300.0
	13	40	101.3	24.31	50	120	24	95.0	32.02	60.0	180.0
	14	38	95.9	54.84	20	360	33	90.9	34.23	30.0	180.0
	15	18	86.7	52.81	30	240	3	93.3	61.82	40.0	180.0

150% of the mean for boys aged 7 and 12-14 years and for girls aged 6-9 and 13 years. In both boys and girls, the maximum BMI was more than 150% of the mean at 7 and 13 years of age. Sleep time decreased with age. Boys aged 14 and girls aged 13-15 were in the short sleep time group.

Next, Table 2 shows obesity (BMI ≧ +20% of mean for each age subjects), breakfast intake, sleep time, and exercise frequency shown by sex for the three age groups of 6-9-year-olds, 10-12-year-olds, and 13-15-year-olds. Of the non-obese, mildly obese, and obese groups the non-obese group accounted for the majority of subjects. Obese subjects among boys were 11 (8.3%) in the 6-9-year-olds, 24 (14.4%) in the 10-12-year-olds, and 15 (10.4%) in the 13-15-year-olds. Among girls, there were 13 (8.8%) in the 6-9-year-olds, 23 (16.2%) in the 10-12-year-olds, and 9 (7.8%) in the 13-15 -year-olds.

As for breakfast intake, there were no boys or girls in the 6-9 year-old group who skipped breakfast regularly, but there were some who ate breakfast only 3 or more times/ week and also, some who rarely ate breakfast 3 times a week. The number of children who ate breakfast every day decreased with age, and in the 13-15 year-old age group those who ate breakfast every day accounted for 129 (87.2%) of boys and 103 (84.4%) of girls.

Sleep time decreased with age, and half of the girls in the 13-15-year-old group belonged to the short sleep time group. Only one boy and no girls among 6-9-year-olds was a short time sleeper.

The frequency of exercise among boys was every day for 163 (34.5%) subjects, 3 or more times/ week for 122 (25.8%), and rarely 3 times/ week for 144 (30.5%). Among girls, 96 (22.0%) subjects exercised every day, 75 (17.2%) subjects exercised 3 or more times/ week, and 193 (44.4%) rarely 3 times/ week. More boys than girls exercised.

Next, a multiple logistic regression analy-

Table 2 Obesity , breakfast-intake, sleep-time and exercise-frequency by sex and age of the groups (%).

	boys				girls			
age groups	6-15	6-9	10-12	13-15	6-15	6-9	10-12	13-15
obesity (1)				n=446				n=405
non-obese	264 (59.2)	76 (56.3)	104 (62.3)	84 (58.3)	239 (59.0)	84 (56.8)	91 (64.1)	64 (55.7)
mildly obese	132 (29.6)	48 (35.4)	39 (23.4)	45 (31.3)	121 (29.9)	51 (34.5)	28 (19.7)	42 (36.5)
obese	50 (11.2)	11 (8.3)	24 (14.4)	15 (10.4)	45 (11.1)	13 (8.8)	23 (16.2)	9 (7.8)
breakfast intake				n=478				n=437
every day	431 (90.2)	142 (92.8)	160 (90.4)	129 (87.2)	402 (92.0)	160 (95.2)	139 (94.6)	103 (84.4)
3 or more times/week	29 (60.9)	7 (4.6)	13 (7.3)	9 (6.1)	23 (5.3)	7 (4.2)	5 (3.4)	11 (9.0)
rarely 3 times/week	14 (9.1)	4 (2.6)	3 (1.7)	7 (4.7)	8 (1.8)	1 (0.6)	2 (1.4)	5 (4.1)
skipped	4 (0.8)	0 (0.0)	1 (0.6)	3 (2.0)	4 (0.9)	0 (0.0)	1 (0.7)	3 (2.5)
sleep time (2)				n=469				n=434
short-time	67 (14.3)	1 (0.7)	10 (5.8)	56 (38.4)	81 (18.7)	0 (0.0)	15 (10.4)	66 (54.1)
long-time	402 (85.7)	149 (99.3)	163 (94.2)	90 (61.6)	353 (81.3)	168 (100.0)	129 (89.6)	56 (45.9)
exercise frequency				n=472				n=435
every day	163 (34.5)	27 (18.0)	51 (29.1)	85 (57.8)	96 (22.0)	15 (9.0)	27 (18.6)	54 (43.9)
3 or more times/week	122 (25.8)	42 (28.0)	60 (34.3)	20 (13.6)	75 (17.2)	37 (22.2)	25 (17.2)	13 (10.6)
rarely 3 times/week	144 (30.5)	66 (44.0)	46 (26.3)	32 (21.8)	193 (44.4)	96 (57.5)	68 (46.9)	29 (23.6)
never	43 (9.1)	15 (10.0)	18 (10.3)	10 (6.8)	71 (16.2)	19 (11.4)	25 (17.2)	27 (22.0)

(1)non-obese: BMI<+10% of mean
mildly obese: BMI +10% to +< 20% of mean
obese: BMI ≧+20% of mean

(2)short-time: less than 8 hours
long-time: 8 hors or more

sis was conducted with binary variable, obese or not, as the dependant variable, and breakfast intake, exercise frequency, and sleep time as explanatory variables for 10-12-year-old and 13-15-year-old subjects by sex. It was found that not a single child in the 6-9-year-old group skipped breakfast or had short sleep time, making analysis of the 6-9-year-old group impossible.

Odds ratios of factors related to obesity based on the multiple logistic regression analysis are shown in Table 3. Consequently, an analysis was conducted for 4 groups of 10-12, and 13-15-year-olds classified by sex, and these results were summarized by using meta-analysis (Mantel-Haenszel method). The summary odds ratio for obesity and breakfast intake among 10-12-year-old boys was 1.322 (95% CI 0.386-4.532), and among girls was 0.539 (95% CI 0.062-4.682). The summary odds ratio for obesity and short sleeping time among 10-12-year-old boys was 0.888 (95% CI 0.235-3.352), and among girls was 1.074 (95% CI 0.317-3.636). The summary odds ratio for obesity and exercise frequency among 10-12-year-old boys was 1.447 (95% CI 0.668-3.135), and among girls was 2.037 (95% CI 0.795-5.222).

The summary odds ratio for obesity and breakfast intake among 13-15-year-old boys was 0.968 (95% CI 0.233-4.022), and among girls was 1.028 (95% CI 0.207-5.121). The summary odds ratio for obesity and short sleeping time among 13-15-year-old boys was 2.738 (95% CI 0.469-15.994), and among girls was 0.517 (95% CI 0.062-4.303). The summary odds ratio for obesity and exercise frequency among 13-15-year-old boys was 2.987 (95% CI 1.103-8.090) ($p<0.05$), and among girls was 0.988 (95% CI 0.331-2.943).

In the meta-analytical summary of the logistic regression analysis, for obesity and exercise frequency among 13-15-year-old boys, the summary odds ratio was significantly higher at 2.987 ($p<0.05$). The other odds ratios for breakfast intake and sleeping time among boys and girls were not significant. The odds ratio for exercise frequency was also insignificant among girls.

Table 3 Logistic regression analysis of breakfast intake, sleep time and exercise frequency in relation to obesity.

age groups		boys	p value	OR	(95% CI)	girls	p value	OR	(95% CI)
10-12	breakfast intake	n=163				n=139			
	every day		–		1		–		1
	non every day		0.657	1.322	(0.386-4.532)		0.576	0.539	(0.062-4.682)
	sleep time								
	long-time		–		1		–		1
	short-time		0.861	0.888	(0.235-3.352)		0.908	1.074	(0.317-3.636)
	exercise frequency								
	doing		–		1		–		1
	never		0.349	1.447	(0.668-3.135)		0.136	2.037	(0.795-5.222)
13-15	breakfast intake	n=142				n=114			
	every day		–		1		–		1
	non every day		0.964	0.968	(0.233-4.022)		0.970	1.028	(0.207-5.121)
	sleep time								
	long-time		–		1		–		1
	short-time		0.263	2.738	(0.469-15.994)		0.542	0.517	(0.062-4.303)
	exercise frequency								
	doing		–		1		–		1
	never		0.031	2.987	(1.103-8.090)*		0.982	0.988	(0.331-2.943)

*:$p<0.05$

Discussion

In the present study it was not possible to clarify all the risks for obesity in children aged from 6 through 15 years. There were not enough subjects for our investigation to find the risk of obesity, we grouped the children as follows: starting with grades 1-3 of elementary school (6-9 years old), then the grades 4-6 of elementary school (10-12 years old), and ending with the grades 1-3 of middle school (13-15 years old). This is because nearly all children aged 6-9 years ate breakfast and got sufficient sleep, and a logistic regression analysis is impossible if there are no samples with these risks.

Therefore, the analysis was conducted by dividing the 10-15- year-old group into four groups by age and sex. The results showed that obesity and exercise frequency were significantly related among 13-15-year-old boys.

Several studies showed that risk factors for weight gain in school age are strongly linked to low physical activity and family environmental factors.[9] Schonfeld-Warden et al. reported that adults who were obese as children have increased mortality independent of adult weight.[10] Strong family influence in childhood, and negative health habits are thought to indicate a strong possibility of lifestyle-related diseases later in adult life.[11)12] Fuentes et al. found that children in the highest tertile of BMI at age 7 had a significantly higher risk of being in the highest tertile of BMI at age 15 compared with children in other tertiles of BMI at age 7.[13] Trost et al. suggested that a significant proportion of overweight preschool children may be at increased risk for future gains in adiposity because of low levels of physical activity during the day.[14] These findings indicate the importance of obesity prevention measures for children aged 6-15 years.

No significant relation was seen between breakfast intake and obesity. Breakfast is eaten between waking time and the start of the school day, and 90% of the subjects ate breakfast every day. Multiple logistic regression analysis is used in determining the kinds of factors that affect the incidence of abnormalities, such as obesity, or calculating the odds ratio for the morbidity risk ratio with consideration of factors related to life-style diseases. In the present study, we analyzed the contribution of the factors of breakfast intake, sleep time and exercise frequency among schoolchildren.[15]

The distributions of lifestyle variables were not constant among schoolchildren, so we had to divide the subjects by sex and age groups for their analysis. We conducted a meta-analytical summary of logistic regression analysis, and found that there was significantly less obesity in 13-15-year-old boys who exercise. This agrees with the report of Saito et al. that in addition to diet, exercise also plays a major role in decreasing obesity.[16−19]

No relation was found between the level of obesity and the length of sleep time or whether or not breakfast was eaten. In the meta-analytical summary of the logistic regression analysis, a significant correlation was seen between obesity and exercise frequency in 13-15-year-old boys. The present study suggests that exercise is effective in the prevention of obesity. The lifestyles of schoolchildren change with age, and distributions of lifestyle-related variables are not constant. For such an inconsistent target, meta-analytical summary for all subjects based on a multiple logistic regression analysis for each group is useful.

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