

Overweight Children at a Primary School in Hirosaki City: A Longitudinal, Individualized, Observational Study

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The 2015 Annual report on growth velocity and physiologic status in schoolchildren revealed that the overweight incidence among fifth grade primary school in Aomori Prefecture was higher than the countrywide average. As a pilot study, overweight fifth grade (age, 10 years) children attending the attached primary school of Hirosaki University, Faculty of Education, were recruited in 2016, after which 6-year longitudinal change in physiological status between the first (age, 6 years) and sixth grades (age, 11 years) were evaluated using somatometric data obtained from the annual health checkup conducted each Spring. Of the 80 fifth graders recruited, none of whom had any underlying diseases affecting physiologic status, 6 (7.5%, 3 boys and 3 girls) were deemed overweight. Subsequently, 20 non-overweight children (10 boys and 10 girls) of the same grade were randomly selected for comparison. We used percent degree of overweight (%DO) for evaluating overweight instead of body mass index. Accordingly, compared with controls, overweight children already exhibited significantly greater weight and %DO at the first grade. Moreover, those who remained being overweight by the fourth grade showed %DO that tended to persist thereafter. Most overweight children exhibited increased annual velocity in %DO between the first and third grades. Overweight children showed varied fluctuations in %DO status throughout 6 years of primary school, whereas non-overweight children showed almost stable %DO within the normal range. The present study indicates the importance of early and sustained health education, particularly during the period before primary school entry until at least before fourth grade.

Keywords: early health education; longitudinal individualized study; overweight; percent degree of overweight; tracking phenomenon

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Introduction

Childhood overweight or obesity often persists into adulthood, thereby subjecting individuals to a higher risk of cardiovascular, metabolic and kidney diseases (Costa-Correia et al. 2018). Further, children with obesity are reportedly also at a high risk of asthma (Lang et al. 2018). The 2015 Global Burden Disease (GBD) Study reported a total of 107.7 million obese children since 1980, with the prevalence of obesity almost doubling in more than 70 countries (GBD 2015 Obesity Collaborators 2017). Thus, the importance of physiologic status awareness in schoolchildren is now considerably growing worldwide (Suginori et al. 1999; Nakano et al. 2010a, b; Davidson and Vidgen 2017). Further, several longitudinal studies have shown that childhood overweight/obesity consequences unexpectedly present earlier than postulated (Costa-Correia et al. 2018). Thus, recent knowledge regarding the “tracking” phenomenon of overweight from school-going

stage into adulthood strongly suggests the importance of early health education (Suginori et al. 1999; Nakano et al. 2010a, b). Early health education, i.e., before tracking of overweight, is desirable and is effective health education preventing future risk of chronic diseases (Brown et al. 2015; Davidson and Vidgen 2017).

According to the 2015 annual report of physiologic status in schoolchildren at Aomori Prefecture (Aomori Prefecture 2016), the incidence of overweight or obesity was markedly higher among fifth grade primary school in this region (approximately 15.1% in boys and 10.5% in girls) than the national average (7.5% in boys and 6.7% in girls). Hence, we aimed to present a detailed temporal course of overweight development over a 6-year period in each overweight fifth grader at a representative primary school in Hirosaki City, Aomori Prefecture.

Methods

A school-site cohort study was conducted on the basis of

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somatometric data obtained from the annual health checkup conducted each Spring at the attached primary school of Hirosaki University, Faculty of Education (APSH), which is one of the largest primary school in Hirosaki City. In 2016, approximately 600 school children had been studying at the APSH, the parents of whom mostly belonged to the middle socioeconomic status and resided within Hirosaki City. According to the 2015 annual report of physiologic status in schoolchildren at Aomori Prefecture (Aomori Prefecture 2016), fifth graders (age, 10 years) attending the aforementioned school were selected. Percent degree of overweight (%DO) was then calculated using the anthropometric expression used in the Ministry of Education, Culture, Sports, Science and Technology, Japan, [i.e., (weight – standardized weight for height)/standardized weight for height \times 100 (%)] with the following classification: > 50%, severe; 30%-50%, moderate; 20%-30%, mild; and > –20% to < 20%, normal (Takaya et al. 2018). We used %DO for evaluating overweight in the study participants, because the Ministry of Education, Culture, Sports, Science and Technology, Japan recommended %DO instead of body mass index (BMI) in school-site health checkup (Takaya et al. 2018; Ministry of Education, Culture, Sports, Science and Technology 2017). First, overweight fifth graders at the APSH were selected based on their 2016 health checkup data and then retrospectively evaluated of longitudinal individualized changes in overweight status between the first (year 2012) and sixth grades (year 2017). For comparison, 20 non-overweight children (10 boys and 10 girls) of the same grade were randomly selected as controls, and were similarly evaluated for longitudinal individualized changes in physiologic status. Because of unexpectedly low incidence of overweight in fifth

graders attending APSH, we evaluated randomly selected 20 non-overweight children for comparison.

Random symbols were used for physiologic data to hide personal information. This study was approved by the ethics committee of Hirosaki University Faculty of Education.

Data for each group were expressed as mean \pm standard deviation. Physiological data comparisons between overweight children and non-overweight children were analyzed using Student's *t*-test, and $p < 0.05$ was considered statistically significant.

Results

A total of 80 fifth graders (35 boys and 45 girls) attending the APSH were identified in 2016: none of those children had underlying diseases affecting physiological status. None of whom had received any medical intervention or consult regarding physiologic status. According to the data obtained from the 2016 annual school health checkup, 6 (7.5%) children (3 boys and 3 girls) were deemed overweight. The mean %DO was $32.9\% \pm 8.9\%$ (range, 23.1%-40.6%) for boys and $26.6\% \pm 2.3\%$ (range, 24.5%-29.1%) for girls. None of the children were severely overweight. In contrast, the mean %DO among the 20 randomly selected non-overweight children (10 boys and 10 girls) was $-1.2\% \pm 8.2\%$ (range, -14.2%-8.8%) for boys and $-5.5\% \pm 8.6\%$ (range, -18.4%-8.8%) for girls. None of the children showed emaciation (< -20% of %DO). Table 1 presents the changes in the height (cm), body weight (kg),

Table 1. Changes in the physiological status taken from annual health check in children deemed overweight in the 5th grade of primary school at 2016 compared to that of children without overweight in the same grade.

	Overweight boy (n = 3)	Non-overweight boy (n = 10)	Overweight girl (n = 3)	Non-overweight girl (n = 10)
1st grade				
Weight (kg)	30.6 \pm 3.3* (28.5-34.4)	21.7 \pm 1.8 (19.4-23.9)	27.2 \pm 3.3* (23.7-30.2)	20.9 \pm 3.0 (15.7-22.9)
Height (cm)	125.2 \pm 2.6* (122.2-127.0)	116.2 \pm 3.7 (111.8-120.6)	118.7 \pm 3.9 (114.8-122.5)	116.1 \pm 5.3 (106-123.3)
%DO (%)	21.0 \pm 12.1* (8.9-33.1)	2.4 \pm 5.5 (-4.6-12.7)	21.9 \pm 5.5* (15.6-25.7)	-1.2 \pm 6.1 (-9.4-8.8)
2nd grade				
Weight (kg)	37.0 \pm 3.5* (34.4-41.0)	24.2 \pm 2.2 (21.1-28.1)	32.5 \pm 3.9* (28.0-34.8)	23.2 \pm 3.3 (17.9-26.1)
Height (cm)	132.0 \pm 3.6* (127.8-134.2)	122.4 \pm 3.6 (117.8-126.7)	126.1 \pm 4.4 (121.1-129.2)	122.3 \pm 5.6 (111.5-129.6)
%DO (%)	28.3 \pm 9.5* (18.5-37.5)	1.4 \pm 6.0 (-7.3-10.3)	26.2 \pm 4.9* (20.9-30.5)	-2.4 \pm 7.4 (-15.2-9.8)
3rd grade				
Weight (kg)	43.9 \pm 4.0* (39.9-47.9)	26.6 \pm 2.1 (22.7-29.4)	38.6 \pm 3.5* (35.1-42.0)	26.2 \pm 3.6 (19.6-28.7)
Height (cm)	138.4 \pm 3.9* (133.9-141.1)	127.9 \pm 3.6 (123.6-132.3)	133.8 \pm 1.9 (132.2-135.9)	128.7 \pm 5.9 (117.6-136.0)
%DO (%)	32.9 \pm 14.4* (16.7-44.1)	0.8 \pm 7.1 (-10.1-12.0)	28.2 \pm 7.2* (20.4-29.6)	-3.5 \pm 6.2 (-11.8-4.4)
4th grade				
Weight (kg)	49.2 \pm 4.3* (46.2-54.1)	29.1 \pm 1.9 (26.9-31.0)	43.5 \pm 1.7* (42.4-45.4)	29.7 \pm 4.7 (21.7-36.0)
Height (cm)	144.9 \pm 4.3* (140.0-148.2)	133.0 \pm 4.1 (128.8-139.2)	141.5 \pm 3.3 (139.0-145.3)	135.0 \pm 6.7 (123.3-145.7)
%DO (%)	29.1 \pm 9.9* (17.7-35.7)	-2.5 \pm 5.5 (-12.6-6.9)	23.4 \pm 3.2* (20.3-26.7)	-4.3 \pm 8.3 (-17.0-9.1)
5th grade				
Weight (kg)	56.4 \pm 3.7* (55.0-60.6)	33.5 \pm 1.9 (31.9-38.2)	50.8 \pm 3.8* (47.8-55.1)	33.3 \pm 5.9 (24.7-43.8)
Height (cm)	150.3 \pm 5.1* (144.4-153.9)	139.1 \pm 4.9 (132.9-149.1)	148.3 \pm 5.1 (144.0-153.9)	141.6 \pm 7.6 (129.2-154.9)
%DO (%)	32.9 \pm 8.9* (23.1-40.6)	-1.2 \pm 8.2 (-14.2-8.8)	26.6 \pm 2.3* (24.5-29.1)	-5.5 \pm 8.6 (-18.4-8.8)
6th grade				
Weight (kg)	58.2 \pm 4.0* (54.8-62.6)	37.6 \pm 3.9 (34.7-44.6)	54.3 \pm 1.8* (52.8-56.3)	38.5 \pm 7.3 (26.6-51.5)
Height (cm)	156.9 \pm 6.9* (149.0-161.9)	146.1 \pm 6.4 (138.8-159.7)	152.7 \pm 4.0 (150.3-157.3)	148.3 \pm 7.6 (136.2-159.9)
%DO (%)	23.2 \pm 15.9* (6.4-37.9)	-3.5 \pm 7.2 (-13.2-5.8)	24.4 \pm 5.2* (18.6-28.6)	-4.6 \pm 8.6 (-15.2-9.8)

Data expressed mean \pm SD; parenthesis means ranges of each respective value; * $p < 0.01$.

%DO, percent degree of overweight.

and %DO (%) in both overweight and non-overweight control children throughout 6 years of primary school (from the first to the sixth grade). All the parameters, except for the height in girls, were significantly greater in overweight children than in non-overweight children. As a reference, we confirmed that both mean height and mean weight among the non-overweight children included herein did not significantly differ from average values determined from the 2016 Japanese nationwide survey in schoolchildren (Ministry of Education, Culture, Sports, Science and Technology 2017).

Regarding longitudinal annual changes in height, weight, and %DO, one boy (subject c in Fig. 1) who was determined to have mild overweight (%DO, 23.1%) in the fifth grade remained within the non-overweight grade throughout the 6-year period except during the fifth grade (Fig. 1C). Thus, this boy had tentative mild overweight only in the fifth grade by chance. The other two boys (subjects a and b in Fig. 1) showed persistent overweight throughout all the 6-year period (Fig. 1C). One girl (subject b in Fig. 2) showed a gradual increase in %DO through the years, whereas another one girl (subject c in Fig. 2) showed a decrease in %DO during the fourth and the sixth grades (Fig. 2C). Another girl (subject a in Fig. 2) showed a stable overweight status through the years (Fig. 2C). These five overweight children showed unstable individualized variations in %DO status, whereas each of non-overweight children showed almost stable or slightly decreased (not increased) annual %DO status within the normal range through the school years despite the increase in the height and the weight (Figs. 1 and 2). Interestingly, children who remained overweight by the fourth grade showed %DO that tended to persist thereafter (boys, a and b in Fig. 1 and girls, a and b in Fig. 2).

Discussion

Childhood overweight or obesity is currently a major global health problem (GBD 2015 Obesity Collaborators 2017). Recent reports have shown that obese children tend to develop not only future lifestyle-related diseases, such as cardiovascular, metabolic and kidney diseases (Costa-Correia et al. 2018), but also present childhood diseases, such as asthma (Lang et al. 2018). Further, studies have reported the existence of a strong association between obesity and persistent high risk for depression in female children (Sutaria et al. 2019). Thus, childhood overweight or obesity is one of the many possible triggers for the onset of various modern lifestyle-related diseases, with this relationship being greater than previously expected (GBD 2015 Obesity Collaborators 2017).

In Aomori Prefecture, Japan, the prevalence of childhood overweight, particularly among fifth graders, is reportedly higher than that of the national average (Aomori Prefecture 2016). Considering that APSH is one of the largest primary school in Hirosaki City, Aomori Prefecture, this pilot study examined the individualized longitudinal

changes in %DO among selected fifth graders attending APSH in 2016. One recent report suggested that even in Japan, %DO in children negatively correlated with the mean annual income of their family (Takaya et al. 2018). However, the parents of most children attending APSH belonged to the middle socioeconomic class. Thus, %DO in most of those children was probably not influenced by their family's socioeconomic or educational status. This may be one reason for relatively low incidence of overweight among children attending APSH that is located even in Aomori Prefecture. Indeed, no significant differences in physiologic status were observed between all the selected non-overweight children and those included in the 2016 Japanese nationwide survey on schoolchildren (Ministry of Education, Culture, Sports, Science and Technology 2017). Therefore, the selected non-overweight children were maintained as controls for %DO and compared with fifth graders deemed overweight in 2016. All the included children demonstrated normal annual height and weight growth velocity, although some fluctuation existed. However, overweight children had already weighed more than non-overweight children upon primary school entry and showed a tendency for increased annual weight velocity between the first and third grades. Moreover, an interesting and different pattern had been observed between overweight and non-overweight children with regard to annual changes in %DO. Although non-overweight children showed nearly stable annual %DO within the normal range throughout the 6-year period, overweight children demonstrated unstable individualized increases and decreases in annual %DO. Of note, most overweight children showed an apparent increase in annual %DO between the first and third grades of primary school. Those who remained being overweight by the fourth grade showed a %DO that tended to persist thereafter. In this context, Nakano et al. (2010b) previously reported that the critical window at which childhood growth velocity was associated with the risk of overweight during adolescence was during 7-11 years in boys and 9-11 years in girls. Despite small sample size, the present individualized, longitudinal, observational study also confirmed those phenomena.

Although the importance of early health education has already been pointed out (Suginori et al. 1999; Nakano et al. 2010a, b; Brown et al. 2015), some difficulties and barriers in the implementation of effective childhood overweight management programs have also been reported (Davidson and Vidgen 2017). Accordingly, studies have shown that although some parents did worry about their children's weight status, others showed a lack of recognition regarding this issue (Davidson and Vidgen 2017). Thus, parents need to be not only encouraged to enroll in childhood overweight or obesity management programs but also led to act beyond awareness of their children's weight status (Davidson and Vidgen 2017). Despite the existing barriers, previous studies (Suginori et

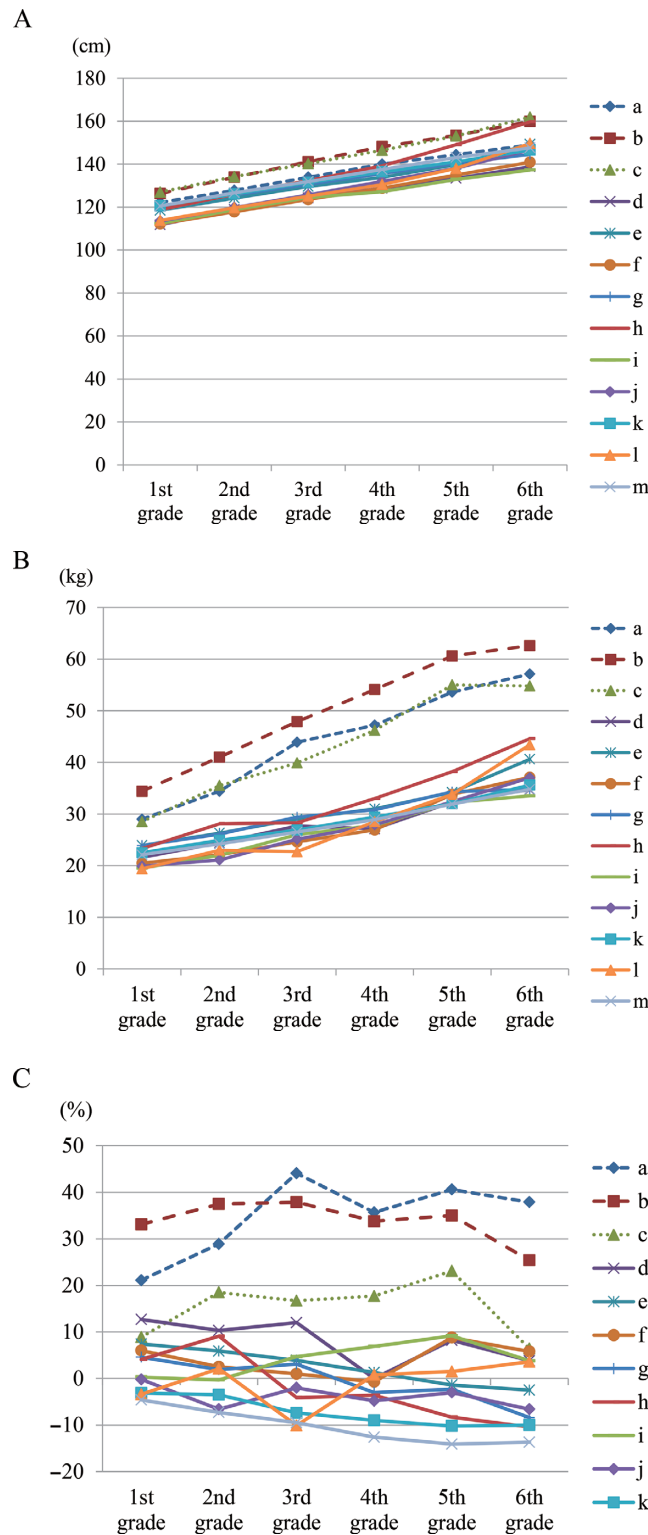


Fig. 1. Longitudinal annual changes in height, weight, and % grade of overweight among enrolled boys.

Graphs show longitudinal changes in annual velocity for height (A), weight (B), and % grade of overweight (C) among each boy from the first to sixth grades of primary school.

A, B: Subjects a, b and c were overweight, whereas subjects e, f, g, h, i, j, k, l, m and n were served as non-overweight controls. Both mean height and mean weight of the non-overweight subjects did not significantly differ from those of school boys included the 2016 Japanese nationwide survey.

C: Boys who exhibited persistent overweight (subjects a, b, and c) showed unstable individualized variations in % grade of overweight status, whereas non-overweight boys showed almost stable annual % grade of overweight within the normal range throughout the school years.

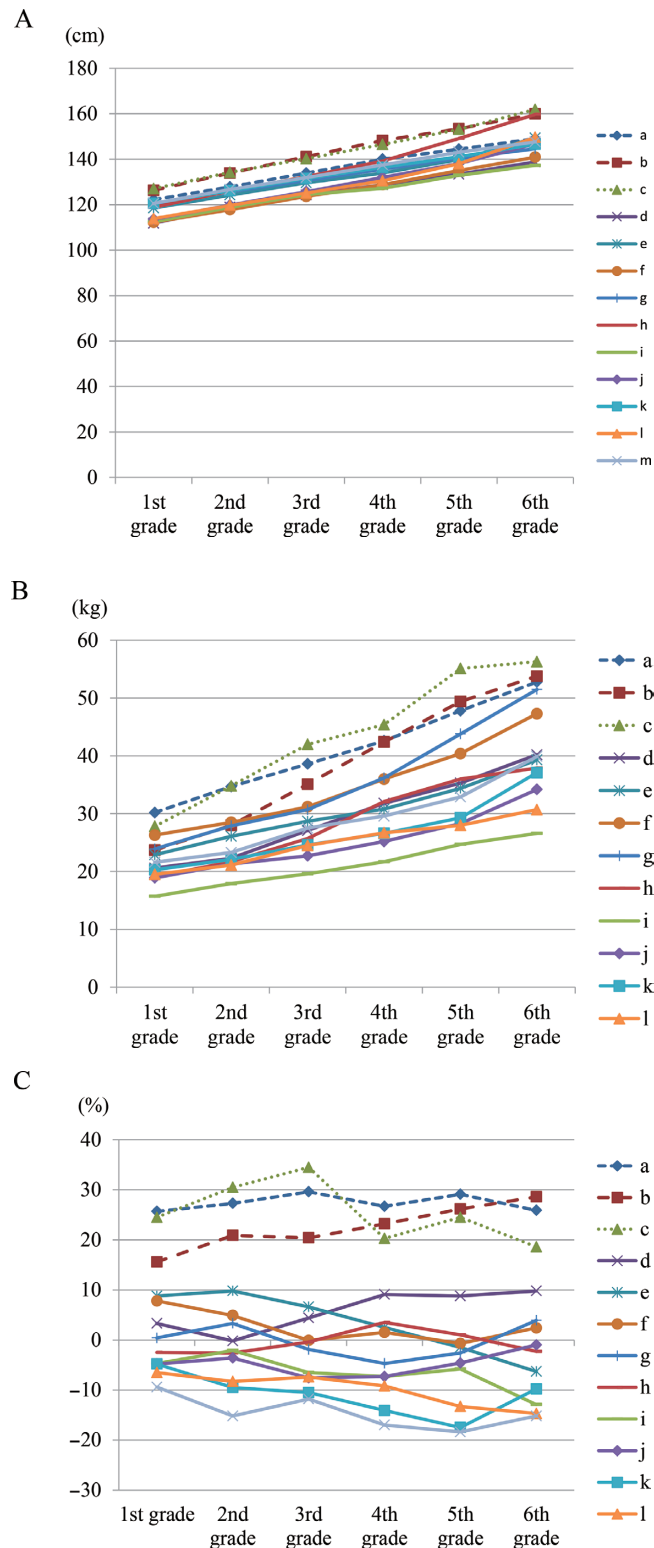


Fig. 2. Longitudinal annual changes in height, weight, and % grade of overweight among enrolled girls.

Graphs show longitudinal annual changes in height (A), weight (B), and % grade of overweight (C) among each girl from the first to sixth grades of primary school.

A, B: Subjects a, b and c were overweight, whereas subjects e, f, g, h, i, j, k, l, m and n were served as non-overweight controls. Both mean height and mean weight of the non-overweight subjects did not significantly differ from those of school girls included the 2016 Japanese nationwide survey.

C: Girls who exhibited persistent overweight (subjects a, b, and c) showed unstable individualized variations in % grade of overweight, whereas each non-overweight girl showed almost stable annual % grade of overweight within the normal range throughout the school years.

al. 1999; Nakano et al. 2010a, b) strongly suggest the need for early and sustained health education not only during the period before primary school entry (Suginori et al. 1999) but also between the first and third grades of primary school (Nakano et al. 2010a, b).

The present study had some limitations. The prevalence of overweight children attending APSH in 2016 was almost the same as that throughout the country (7.5% in boys and 6.7% in girls) but was lower than that throughout Aomori Prefecture (approximately 15.1% in boys and 10.5% in girls). Moreover, the sample size of this study was rather small. Thus, the findings presented herein might constitute relatively small reference for future studies. However, to our knowledge, published reports from longitudinal, individualized, observational studies focusing on each overweight/obese child have remained scanty (Suginori et al. 1999; Nakano et al. 2010b). In this context, our present study is a detailed individualized school-site cohort study using %DO instead of BMI, that is, more likely for evaluating recent healthcare in schoolchildren in Japan. We believe that our findings will help establish early healthcare education programs for the management of overweight/obesity among children.

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Conflict of Interest

The author has no conflict of interest.

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