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Short Communication

The Accelerated Increase in Lean Body Mass of Pre-pubescent Japanese Boys at 10 to 11 Years of Age

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Abstract

The present study investigated changes in body composition in relation to growth to evaluate at what age Japanese children begin their pre-pubescent growth spurt. Children aged 9 were followed to age 10 (The age 9 group), and those aged 10 were followed to age 11 (The age 10 group). The increase in lean body mass per one-year increment of body height (ΔLBM/ΔBH) in the age 10 boys group was significantly higher than that in the age 9 boys group. In both the age 9 and 10 boys groups, the high Body Mass Index (BMI) boys showed greater mean ΔLBM/ΔBH than that for the normal BMI boys. Our results of accelerated ΔLBM/ΔBH from age 10 to 11 in Japanese boys hypothesize that an increase in LBM demonstrates pre-pubescent growth.

Key words: Bioelectrical impedance, Body composition, Child, Growth, Longitudinal studies

Introduction

There have been several attempts to show changes of body composition in relation to children's growth patterns by using bioelectrical impedance analysis (BIA)[1-7]. However, there have been very few longitudinal studies regarding body composition changes in a prescribed population of children. This study is a one-year prospective collaborative research study in which Japanese children of 9 years of age were followed to age 10 and children of 10 years of age were followed to age 11, investigating changes in body composition in relation to growth to evaluate at what age Japanese children begin their pre-pubescent growth spurt.

Subjects and Methods

Subjects are two distinct age groups of school children aged 9 and 10 in 1995 in H-Town in Gifu Prefecture, Japan. Consent to participate in this study was obtained from each of them and their parents. Forty-three children aged 9 were followed to age 10 (23 boys, 9.7 ± 0.3 years (mean ± SD); 20 girls, 9.6 ± 0.2 years), and fifty children aged 10 were followed to age 11 (23 boys, 10.6 ± 0.3 years; 27 girls, 10.6 ± 0.2 years). All subjects were healthy and not undergoing medical treatment or taking medication.

Measurements for body height (BH), body weight (BW) and percentage of body fat (Fat %) were performed for each age group, initially in 1995 and the subsequent year. Fat % for each subject was estimated using bioelectrical impedance analysis (BIA). Bioimpedance was measured using a four-terminal impedance analyzer (TBF-202 TANITA, Japan; constant current: 0.8 mA, 50 kHz), which was the updated model of TBF-101. Subjects stood barefoot on the scale of a four-terminal impedance analyzer. The electrodes (injector and detector) were placed just below the balls of the feet and the heels. Bioelectrical impedance (BI) was then measured. The impedance analyzer includes scales for measuring BW and BH so that these could be measured at the same time.

All measurements were done in accordance with the guidelines established by the Japan BI Method Meeting[5] : 1) measurements should be carried out two hours after breakfast; 2) room temperature should be at about 25 degrees Celsius; 3) exercise that could result in dehydration or increased body temperature should be prohibited for at least two hours before measurement; and 4) the soles of the feet should be cleaned before measurement. The formulas experimentally derived were used to calculate the estimated body density (BD)[8], and Fat % was calculated using the formula reported by Brozek et al.[9]. Fat mass (FM) and lean body mass (LBM) were calculated from the following formulas:

Boys: $BD = 1.1643 - 0.118 * BW (kg) * Z (ohms) / [BH (cm)]^2 + 0.0000049 * Z (ohms)$

Girls: $BD = 1.0907 - 0.112 * BW (kg) * Z (ohms) / [BH (cm)]^2 + 0.000134 * Z (ohms)$

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Fat % = [(4.570 / BD) - 4.142] * 100
FM (kg) = BW (kg) * Fat% / 100
LBM (kg) = BW (kg) - FM (kg)
[BH : body height (cm) , BW : body weight (kg), Z : bioelectrical impedance (ohms)]
Body Mass Index (BMI) was calculated from BH and BW according to the following equation:

$$BMI = BW (kg) / [BH (m)]^2$$

[BH : body height (m) , BW : body weight (kg)]
Statistical analysis were conducted as follows:

1) Changes in BH, BW, Fat %, LBM and FM for one year, in both age 9 and age 10 groups, were examined using the Wilcoxon signed-ranks test.

2) Increase of LBM and FM per one-year increment of body height (ΔLBM/ΔBH, ΔFM/ΔBH) were compared i) between genders both in the age 9 and age 10 groups, and ii) between the age 9 and age 10 group by gender by applying the Wilcoxon-Mann-Whitney tests.

3) Subjects of 80th percentile for BMI were defined as high BMI subjects, and others as normal BMI subjects in both age 9 and age 10 groups. Values of 80th percentile for BMI were 17.6 for boys and 16.8 for girls in the age 9 group, and 19.1 for boys and 18.2 for girls in the age 10 group. ΔLBM/ΔBH and ΔFM/ΔBH between high BMI subjects and normal BMI subjects were then compared, respectively, by applying the Wilcoxon-Mann-Whitney tests.

Results

1) The descriptive data are shown in Table1. In the age 9 group, both LBM and FM for both genders increased for one year ($p < 0.001$ for both). In the age 10 group, LBM for boys increased after one year ($p < 0.001$) and FM for boys remained the same, while both LBM and FM for girls increased for one year ($p < 0.001$ for both).

2) In the age 9 group, no gender differences were found in ΔLBM/ΔBH from age 9 to 10. In the age 10 group, ΔLBM/ΔBH for boys from age 10 to 11 was significantly greater than that for girls ($p < 0.01$) (Table 2), while there were no significant differences in ΔFM/ΔBH between boys and girls in either age group. ΔLBM/ΔBH for girls between the age 9 and age 10 groups did not show significant difference. However, ΔLBM/ΔBH for boys in the age 10 group was greater than that in the age 9 group ($p < 0.05$) (Table 2). There were no significant differences in ΔFM/ΔBH for either boys or girls among the two age groups.

3) The high BMI boys showed greater ΔLBM/ΔBH than the normal BMI boys both in the age 9 and the age 10 groups ($p < 0.05$; $p < 0.01$, respectively), while there were no significant differences in ΔFM/ΔBH between the high BMI and normal BMI boys in either age group (Table 3). No significant differences were found in ΔLBM/ΔBH and ΔFM/ΔBH between the high BMI and the normal BMI girls in either age group (Table 3).

Discussion

The four-terminal bio-impedance method has been widely used to estimate body fat[1-7]. Especially in Japan, the newly developed machine (TBF-series, TANITA) which has four-terminal electrodes below the feet is now commonly used because of its convenience and reliability. Tanaka et al. reported that the correlation coefficient for the Fat % between bio-impedance and hydrodensitometry methods was 0.73 in males and 0.67 in females at age 18-50, and Fat % in female over age 50 tended to be overestimated as compared with hydrodensitometry method [10]. However, Sakamoto et al. reported that the correlation coefficient for Fat % was 0.85 in males and 0.84 in females from age 6 to 17[11], and demonstrated its reliability[12].

In the present study our results demonstrated that girls developed with continuous increase in Fat % at 9-11 years of age, while boys of the same age developed with no significant change in Fat %. In order to further measure and evaluate changes in body composition, we applied the ratio of LBM with body height growth. The resulting ratio between the above mentioned components represented clearly an increase in LBM by muscle mass growth together with an increase in body height growth. Regarding the increasing ratio of LBM with height growth, the

Table 1 Physical characteristics of subjects.

Boys	Median (interquartile range: 25th to 75th percentile)										
	age 9 group (n = 23)					age 10 group (n = 23)					
	at age 9		1 year after			at age 10		1 year after			
ΔLBM/ΔBH (kg/cm)	134.6	(129.7 - 138.8)	141.1	(135.9 - 144.1)	***	137.3	(132.1 - 140.1)	143.5	(138.5 - 147.2)	***
ΔFM/ΔBH (kg/cm)	28.8	(27.0 - 31.5)	33.3	(29.9 - 37.7)	***	32.0	(27.7 - 35.5)	36.9	(31.7 - 42.9)	**
Fat % (%)	17.6	(15.6 - 20.2)	15.9	(14.5 - 21.0)		20.4	(17.5 - 22.6)	19.1	(16.6 - 21.6)	
LBM (kg)	24.1	(22.1 - 25.5)	26.8	(23.8 - 30.4)	***	25.1	(21.8 - 28.1)	30.1	(26.1 - 34.1)	***
FM (kg)	5.2	(4.1 - 6.0)	5.4	(4.4 - 9.2)	***	6.4	(5.2 - 8.0)	6.9	(5.3 - 9.1)	

Girls	Median (interquartile range: 25th to 75th percentile)									
	age 9 group (n = 20)					age 10 group (n = 27)				
	at age 9		1 year after			at age 10		1 year after		
ΔLBM/ΔBH (kg/cm)	133.1	(129.8 - 138.4)	140.9	(136.8 - 147.4)	***	137.0	(135.1 - 144.7)	145.0	(142.5 - 152.0)	***
ΔFM/ΔBH (kg/cm)	28.7	(27.2 - 31.8)	35.0	(32.3 - 37.9)	***	31.9	(27.6 - 36.9)	37.5	(33.2 - 42.8)	**
Fat % (%)	14.5	(14.5 - 18.0)	18.3	(17.0 - 19.6)	***	17.1	(13.4 - 20.8)	18.0	(14.5- 21.0)	**
LBM (kg)	24.1	(23.1 - 25.8)	28.5	(26.8 - 30.7)	***	26.0	(23.4 - 29.1)	30.2	(28.0 - 33.2)	***
FM (kg)	4.7	(4.0 - 5.8)	6.3	(5.5 - 7.2)	***	5.7	(4.1 - 7.2)	6.8	(4.7 - 9.6)	***

Fat % = body fat percentage ; LBM = lean body mass ; FM = fat mass.
** $p < 0.01$, *** $p < 0.001$ compared to the initial age by Wilcoxon signed-ranks tests.

Table 2 Values of median, 25 percentile and 75 percentile of ΔLBM/ ΔBH and ΔFM/ ΔBH both in age 9 and 10 groups.

Boys	Median (interquartile range: 25th to 75th percentile)				
	age 9 group		age 10 group		
ΔLBM/ ΔBH(kg/cm)	0.549	(0.460 - 0.688)	0.702	(0.525- 0.858)	*
ΔFM/ ΔBH(kg/cm)	0.084	(0.020 - 0.217)	0.111	(0.005 - 0.220)	

Girls	Median (interquartile range: 25th to 75th percentile)				
	age 9 group		age 10 group		
ΔLBM/ ΔBH(kg/cm)	0.521	(0.471 - 0.574)	0.551	(0.477 - 0.621)	##
ΔFM/ ΔBH(kg/cm)	0.182	(0.112 - 0.292)	0.136	(0.103 - 0.255)	

ΔLBM/ ΔBH = increase in lean body mass (LBM) per one-year increment of body height (BH).
ΔFM/ ΔBH = increase in fat mass (FM) per one-year increment of body height (BH).
* p < 0.05 compared to age 9 group by Wilcoxon-Mann-Whitney tests.
p <0.01 compared to boyx subjects by Wilcoxon-Mann-Whitney tests.

Table 3 Comparison between high BMI and normal BMI subjects for ΔLBM/ ΔBH and ΔFM/ ΔBH in age 9 and 10 groups.

Boys	Median (interquartile range: 25th to 75th percentile)									
	age 9 group					age 10 group				
	Normal BMI (n = 18)		High BMI (n = 5)			Normal BMI (n = 18)		High BMI (n = 5)		
ΔLBM/ ΔBH(kg/cm)	0.432	(0.483 - 0.664)	0.475	(0.666 - 0.805)	*	0.624	(0.523 - 0.786)	1.149	(0.834 - 1.228)	**
ΔFM/ ΔBH(kg/cm)	0.020	(- 0.073 - 0.128)	0.244	(0.032 - 0.358)		0.122	(- 0.008 - 0.229)	0.024	(- 0.246 - 0.212)	

Girls	Median (interquartile range: 25th to 75th percentile)							
	age 9 group				age 10 group			
	Normal BMI (n = 16)		High BMI (n = 4)		Normal BMI (n = 22)		High BMI (n = 5)	
ΔLBM/ ΔBH(kg/cm)	0.515	(0.471 - 0.560)	0.550	(0.461 - 0.610)	0.547	(0.474 - 0.620)	0.593	(0.428 - 0.807)
ΔFM/ ΔBH(kg/cm)	0.155	(0.112 - 0.267)	0.267	(0.132 - 0.463)	0.134	(0.102 - 0.222)	0.242	(0.020- 1.005)

ΔLBM/ ΔBH = increase in lean body mass (LBM) per one-year increment of body height (BH).
ΔFM/ ΔBH = increase in fat mass (FM) per one-year increment of body height (BH).
BMI = body mass index.
* p < 0.05, ** p <0.01 compared to normal BMI subjects by Wilcoxon-Mann-Whitney tests.

ratio at 10-11 years of age for boys was greater than that at 9-10 years of age, while the ratio for girls was not significantly different despite the fact that both boys and girls had a continuous increase in LBM at 9-11 years of age.

It is evident that the growth spurt in Japanese boys starts at the mean age of 11.1 and at the mean age of 9.4 in girls[13]. These growth spurts signal the beginning of gender difference[14]. Derived from our results of accelerated ratio of LBM per one-year increment of body height, we hypothesize that changes in body composition lead to maturation with a growth spurt from age 10 to 11 in boys.

Considering the differentiation established by BMI, we could observe higher increases in LBM per one-year increment of body height for the high BMI boys, both in the age 9 and 10 groups in the present study. In our previous two-year cohort study (1994-1995), involving 147 children aged 10-11 in Gifu Prefecture, we had suggested that the high BMI boys had shown larger serum total cholesterol reduction than the normal BMI boys from age 10 to 11[15]. A higher increase in LBM per one-year increment of body height for the high BMI boys from age 10 to 11 shown in this study is likely connected with the reduction of total cholesterol for high BMI boys of the same age. This is a pilot study conducted within a small population. However, we succeeded in showing the significant change in body composition from age 10 to 11 in Japanese boys, and hypothesize that increase in LBM demonstrates pre-pubescent growth. Further investigation in a large population is needed to elucidate the roles of cholesterol and body fat in the initial stage of transition from childhood to puberty.

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