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Original Article

A Cross-Sectional Study for a Reference Model of Body Composition in Japanese Children Aged 3 to 10 Years

Keisuke Teramoto[1]*, PhD; Kodo Otoki[2], MSc; Erina Muramatsu[3], PhD; Yui Kataoka[4], MSc; Chika Oya[5], MSc; Yujiro Ishihara[6], MSc; Shuichi Komiya[7], BA

[1]Aichi University of Education, Japan
[2]Kurume University, Japan
[3]National Institute of Technology, Suzuka College, Japan
[4]Kyushu Women's Junior College, Japan
[5]Humanitec Junior College, Japan
[6]Higashi Chikushi Junior College, Japan
[7]Kyushu University, Japan

Corresponding author:* Keisuke Teramoto, PhD; Hirosawa 1, Igaya-cho, Postal code: 448-8542, Aichi Prefecture, Japan. **Tel: +81-566-262467; **Fax:** +81-566-262467; **Email:** teramoto@auecc.aichi-edu.ac.jp

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Abstract

Background: The purpose of this study was to clarify the standard values of body composition for Japanese preschool and postschool-age children according to age and gender.
Methods: The population of this cross-sectional study comprised 4,289 children (2,183 boys and 2,106 girls) aged 3 to 10 years and they were assessed during the period of 2003-2018. Anthropometric variables and body composition were measured using bioelectrical impedance analysis. The cut-off points for body mass index (BMI) calculated using Cole's LMS method were set at the 25th and 75th percentile values for age and sex to provide a reference model for Japanese children. Differences among age and sex groups were analyzed by two-way ANOVA ($P<0.05$).
Results: Height and weight increased significantly with age irrespective of sex. BMI component showed a higher fat-free mass index (FFMI) in boys and a higher fat mass index (FMI) in girls with transition from early childhood. These features were more pronounced when expressed in terms of quantity (fat mass or fat-free mass, kg), but the same result was obtained when expressed as an index (FMI or FFMI, kg/m^2).
Conclusion: Based on subjects from a large data set, this study established age- and sex-related body composition standards for Japanese before- and after-school children. There were also clear gender and age differences in body composition at this age. The results of this study will serve as basic data for various future pediatric studies.

Keywords: Japanese, Child, Growth reference, Body composition, LMS method

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1. Introduction

Overweightness and obesity are often associated with unhealthy lifestyles in adulthood, and have already been identified as risk factors for diabetes, hypertension, and cardiovascular disease (1). Based on one previous report, childhood obesity is also the leading cause of pediatric hypertension, and overweight children are at a higher risk of developing a number of chronic conditions such as diabetes mellitus, coronary heart disease, and orthopedic disorders (2). Furthermore, studies on the relationship between BMI and obesity in children (3-6) have shown that being overweight or obese in childhood is associated with overweightness or obesity in later adulthood (7) and with an increased risk of morbidity and mortality from lifestyle-related diseases (8).

A national epidemiological survey showed that the prevalence of childhood obesity in 2006 were 8.9% for boys and 5.3% for girls, which were 3.6 and 4.7 times higher than the corresponding values in 1996, respectively (6). In a study on Japanese children, Kotani and colleagues (9) reported that the frequency of obesity decreased from 5% to 3% between 1974 and 1979, then increased from 3% to 11% between 1979 and 1995. Cohort research has shown that the frequency of overweightness and obesity in childhood increased from infancy to primary school age (10). Obesity in childhood is likely to continue thereafter, and the tendency for obesity in 3-year-old children is easy to track up to the 4th grade (11).

Despite the rapid increase in childhood obesity in the United States, Europe, and developing countries, there is still a lack of classification and standardized data on body composition in the background. In Japan, data on current indicators of body composition in relation to the risks of obesity or lifestyle-related diseases are scarce, although the Japanese Ministry of Health, Labour and Welfare (12) reported data for childhood height and body mass. Furthermore, little is known about age- and sex-related patterns of change in body composition in children (13).

Various anthropometric indices have been proposed as proxies for abdominal fat to assess the risk of major chronic and lifestyle-related diseases in overweight and obese individuals. The most widely used measure is body mass index (BMI); however, this index may not be the most appropriate predictor of health risk because it does not clarify whether an increase in the body mass of a child is caused by an increase in fat mass (FM) or a reduction in fat-free mass (FFM). Since BMI is an inaccurate estimate of body fatness (14, 15), it is necessary to measure body composition using bioelectrical impedance analysis (BIA) (16). BIA is an appealing tool for in vivo assessment of body composition and provides reproducible data that can be used for evaluating FFM and FM. As BIA is portable, noninvasive, inexpensive and easy to use, it has great advantages for application to children (17, 18). It is particularly attractive for determining body composition in children compared with other methods which require complicated procedures (e.g. underwater weighing) or radiation exposure (e.g. neutron activation). This makes BIA ideal for studies conducted on large populations.

Based on the above, there is a need to acquire body composition data for children with a standard body shape for comparison with data related to children in various situations. Based on the following approach, the present study attempted to establish standard values of body composition for Japanese pre-school and post-school-age children in relation to age and gender.

1) The study subjects were from a large data set.
2) BMI percentile values were used to select normative subjects.
3) Normalized values were calculated by the LMS method to establish BMI cut-off values.

2. Methods

In this cross-sectional study, all measurements were performed at the same facility during the period 2003-2018. Although the data in this study were measured over a long period of time, the Japanese association for human auxology has showed that “it is appropriate to continue to use the reference values calculated from the anthropometric data published by the Ministry of Health, Labour and Welfare and the Ministry of Education, Culture, Sports, Science and Technology in 2000 as standard values when evaluating the anthropometric status of Japanese children” (19). Therefore, our study was based on the idea that the body size of Japanese children did not change significantly during this period. Two-to-thirteen-year-old healthy Japanese children (4,974 children) were recruited for a cross-sectional data of the body composition reference study through kindergarten or after-school children’s center and their parents provided informed consent prior to the measurements. Children younger than 3 years of age and older than 11 years were excluded because this study included 1) preschool-aged children and 2) children up to the age of 10 for whom basic data were lacking. In addition, children (685 children) with missing data on exposure and outcome variables were excluded. Therefore, the study population consisted of 4,289 children (2,183 boys and 2,106 girls) between the ages of 3 and 10 years. To determine the age groups, the children were divided into age groups using the age on the date of measurement; for example, children aged 3.0-3.9 months were placed in the 3 years group.

The measurements were performed in a room at around 23 degrees Celsius, with the subjects wearing thin underwear. Body weight was measured to the nearest 0.02 kg on a calibrated balance-beam scale with the subjects wearing light underwear, and height was measured to the nearest 0.1 cm. Measurements were conducted according to the method of Komiya and colleagues (20). BMI (kg/m^2) was calculated as body weight/height^2.

BIA measurements were performed 2–3 h after the last meal. Determinations of impedance were made using a four-terminal impedance analyzer (TP-95K, Toyo Physical, Japan). This analyzer was developed based on the relationship between total body water using the deuterium oxide (D_2O) dilution method content and bio-impedance values. Since BIA and total body water (TBW by D_2O dilution) data also indicated a very close correlation in 4- to 6-year-old children (21), we felt justified in taking BIA data as a measure of body composition in children. Each subject was fully clothed except for shoes and socks, and lay supine on a bed with the limbs extended away from the trunk. After cleaning all skin contact areas with alcohol, current electrodes (Red Dot-2330; 3M Health Care, USA) were placed on the dorsal surfaces of the right hand and foot at the distal metacarpals and metatarsals, respectively; detector electrodes were applied at the right pisiform prominences of the wrist and between the medial and lateral malleoli at the ankle. This bioelectrical impedance analyzer generated an excitation current of 500 mA at a single frequency of 50 kHz. Before each testing session, the calibration of the unit was checked using a 400-Ω precision resistor.

FFM was calculated using the equation of Kushner and co-workers (22) and the total body water (TBW) component (hydration) of FFM (23). FM was calculated as the difference between body weight and FFM. Both FFM and FM were divided by stature^2 to give FFMI and FMI (BMI=FFM, kg/ height, m^2+ FM, kg/ height, m^2). These two component indices are known as the FFM index (FFMI) and FM index (FMI), both being discrete and adjusted for body size.

To calculate the BMI-for-age, we used Cole's LMS method (24) for constructing normalized growth standards, which refers to the Box–Cox transformation power (L), the median (M) and the coefficient of variation (S). BMI cut-off points were set at the 25th, 50th and 75th percentile BMI-for-age values in order to provide a reference model of Japanese children for each age and sex group. Hence, 2,022 children with <25th and >75th percentile BMI-for-age were excluded, and 2,267 children (1,146 boys and 1,121 girls) with a standard body shape (25th to 75th percentile BMI-for-age) were included in the final analysis. Afterwards, this study presented body composition data for 2,267 children.

The statistical analysis program SPSS ver.24 (IBM, Japan) was used for the statistical analysis. The results were presented as mean±standard deviation (SD). Differences among age and sex groups were analyzed by two-way ANOVA. When overall differences were significant with ANOVA, post hoc comparisons were performed with Bonferroni test. Differences at P<0.05 were considered as statistically significant. This study was conducted in compliance with the Declaration of Helsinki, the Ethical Guidelines for Clinical Research, and the Act on the Protection of Personal Information. Furthermore, this study received ethical approval from the research ethics committee, Aichi University of Education, Japan, during the research period. Furthermore, we structured and checked our paper using "STROBE Statement-Checklist of cross-sectional studies"(25).

3. Results

The mean and standard deviation values for the physical characteristics in each subject group are shown in Table 1 and 2, and as graphical representations in Figures 1 to 7. Following adjustment by Cole's LMS method, the cut-off values for the BMI 25th and 75th percentiles for each group were 14.89 and 16.40 kg/m^2, 14.63 and 16.19 kg/m^2, 14.45 and 16.15 kg/m^2, 14.53 and 16.55 kg/m^2, 14.94 and 17.54 kg/m^2, 15.07 and 17.87 kg/m^2, 15.32 and 18.54 kg/m^2, and 15.97 and 19.51 kg/m^2 for boys aged 3 to 10 years, respectively. The corresponding values for girls were 14.95 and 16.28 kg/m^2, 14.56 and 16.14 kg/m^2, 14.36 and 16.14 kg/m^2, 14.38 and 16.28 kg/m^2, 14.67 and 16.54 kg/m^2, 14.71 and 17.48 kg/m^2, 15.20 and 17.93 kg/m^2, and 15.57 and 18.71 kg/m^2, respectively. The average height and weight values for boys and girls between the ages of 3 and 10 in this study were comparable to the 2019 standards for Japanese children reported by the Japanese Ministry of Health, Labour and Welfare (26).

Height and weight increased significantly with age but there was a sex difference in weight and no sex difference in height in Figures 1 and 2 (Height Sex; F=1.16, P=0.283, Age; F=1737, P<0.001, Weight Sex; F=22.6, P<0.001, Age; F=1898, P<0.001). By multiple comparisons, a gender gap for weight appeared at the age of 10along with significant age differences between all ages. BMI showed a significant sex- and age-related change (Sex; F=72.1, P<0.001, Age; F=270.1, P<0.001) and interaction effects (F=6.86, P<0.001) in Figure 3. However, there were signs of a rebound around age 6, indicating a gender difference after this age based on multiple comparisons.

Figures 4 and 5 illustrate the components FFM and FM of the weight in Figure 2, respectively. Both components showed a significant sex- and age-related change (FFM Sex; F=114.4, P<0.001, Age; F=1112, P<0.001, FM Sex; F=78.2, P<0.001, Age; F=315.2, P<0.001); in addition, after 4 years of age, boys showed significantly higher values of FFM compared to girls, while girls showed significantly higher values of FM compared to boys. Similarly, Figures 6 and 7 show the components FFMI and FMI of the BMI in Figure 3. Both components showed a significant sex- and age-related change (FFMI Sex; F=188.6, P<0.001, Age; F=21.5, P<0.001, FM Sex; F=76.2, P<0.001, Age; F=41.1, P<0.001), and the F-values for age were lower for the relative values per body weight (FFMI and FMI) compared with the absolute values (FFM and FM). After the age of 4, similar sex differences were observed as in FFM and FM, but there were few differences between the ages. In other words, as shown in each figure, the BMI component showed a higher FFMI in boys and a higher FMI in girls with transition from

Table 1: Body composition values by sex and age in Japanese boys with a standard body shape

	Boys							
Age Group	**3 years old**	**4 years old**	**5 years old**	**6 years old**	**7 years old**	**8 years old**	**9 years old**	**10 years old**
All Subject Number	194	545	563	447	114	**112**	**128**	**80**
25-75%ile Subject Number	103	273	304	234	66	57	67	42
Age, month	42.4±3.3	53.3±3.4	65.2±3.3	76.2±3.0	89.1±3.5	101.8±3.2	113.0±3.5	124.9±3.6
	(36-47)	(48-59)	(60-71)	(72-83)	(84-95)	(96-107)	(108-119)	(120-131)
Height, cm	96.7±4.1	102.9±4.3	109.4±4.5	114.8±4.4	120.1±4.9	127.9±4.9	132.4±6.1	138.9±6.3
	(87.8-107.3)	(91.1-115.0)	(97.4-122.3)	(104.5-127.0)	(105.2-132.4)	(115.2-139.1)	(114.0-144.9)	(121.6-153.9)
Weight, kg	14.6±1.3	16.3±1.4	18.2±1.6	20.4±1.8	23.1±2.1	26.7±2.4	29.5±3.2	33.9±4.0
	(12.1-17.8)	(12.5-20.7)	(14.1-23.1)	(16.4-24.6)	(18.8-28.3)	(22.3-32.0)	(21.6-35.8)	(25.3-45.2)
Body Mass Index, kg/m^2	15.6±0.4	15.4±0.4	15.2±0.5	15.4±0.6	16.0±0.8	16.3±0.7	16.8±0.9	17.5±1.1
	(12.9-16.3)	(14.6-16.2)	(14.5-16.2)	(14.5-16.6)	(14.9-17.4)	(15.1-17.9)	(14.4-18.5)	(16.1-19.3)
Total Body Water, kg	8.79±1.13	10.18±1.20	11.50±1.34	12.71±1.42	14.21±1.53	16.17±1.70	17.40±2.08	19.40±2.83
	(6.18-11.47)	(6.53-14.24)	(7.87-15.99)	(9.38-15.90)	(9.56-18.18)	(13.26-19.98)	(12.46-21.83)	(14.19-28.61)
Fat-Free Mass, kg	11.42±1.47	13.29±1.57	15.11±1.76	16.77±1.87	18.83±2.03	21.49±2.26	23.23±2.78	26.01±3.80
	(8.00-12.90)	(8.50-18.60)	(10.30-21.00)	(12.40-21.00)	(12.70-24.10)	(17.60-26.60)	(16.60-29.10)	(19.00-38.40)
Fat-Free Mass, %	80.0±6.5	80.7±5.9	82.4±6.1	80.8±5.8	80.9±8.2	80.8±6.5	75.5±8.6	81.3±6.2
	(58.5-94.7)	(63.9-95.1)	(65.7-95.4)	(65.9-94.5)	(56.2-95.4)	(52.9-93.3)	(53.6-92.0)	(72.7-95.3)
Fat Mass, kg	3.19±0.94	3.00±0.97	3.10±1.11	3.59±1.09	4.29±1.33	5.20±1.30	6.22±1.88	7.87±2.39
	(0.74-6.22)	(0.74-5.55)	(0.84-6.50)	(1.16-7.60)	(2.10-8.32)	(2.66-7.96)	(1.86-11.46)	(2.10-13.82)
Fat Mass, %	20.0±6.5	19.3±5.9	17.6±6.1	19.2±5.8	19.1±8.2	19.2±6.5	24.5±8.6	18.7±6.2
	(5.3-41.5)	(5.0-36.1)	(4.6-34.7)	(5.5-34.1)	(4.6-43.9)	(6.7-47.1)	(8.0-46.4)	(4.7-27.3)
FFMI, kg/m^2	12.16±0.99	12.53±0.91	12.60±0.93	12.70±0.89	13.03±0.83	13.12±0.84	13.22±0.93	13.43±1.20
	(10.27-12.40)	(10.11-14.99)	(9.89-15.18)	(10.68-14.91)	(11.42-15.24)	(11.45-15.17)	(11.49-15.13)	(11.79-16.21)
FMI, kg/m^2	3.41±0.98	2.84±0.90	2.59±0.92	2.72±0.81	2.98±0.93	3.18±0.78	3.55±1.04	4.09±1.28
	(0.71-5.78)	(0.68-5.10)	(0.68-5.24)	(0.85-4.97)	(1.33-5.87)	(1.49-4.93)	(1.06-6.65)	(1.32-7.37)

Mean±Standard Diviation, In parenthesis (Minimum value-Maximum value); The body composition of 2,267 Japanese children sampled using Cole's LMS method is shown in Table 1 and 2.

Table 2: Body composition values by sex and age in Japanese girls with a standard body shape and statistics data for sex- and age-related differences analyzed by two-way

	Girls								Difference					
Age Group	**3 years old**	**4 years old**	**5 years old**	**6 years old**	**7 years old**	**8 years old**	**9 years old**	**10 years old**	**Sex**		**Age**		**Sex*Age**	
All Subject Number	**205**	**480**	**527**	**424**	**117**	**108**	**136**	**109**	**F**	**P**	**F**	**P**	**F**	**P**
25-75%ile Subject Number	98	257	288	226	65	57	72	58						
Age, month	43.0±3.3	53.4±3.5	65.5±3.5	75.6±2.9	89.6±2.9	101.3±3.3	113.1±2.9	124.6±3.1	0.10	0.920	13695	<0.001	1.36	0.219
	(36-47)	(48-59)	(60-71)	(72-83)	(84-95)	(96-107)	(108-119)	(120-131)						
Height, cm	96.5±4.7	101.8±4.0	109.0±4.6	114.4±4.3	120.3±5.4	127.0±6.3	133.1±6.4	138.8±6.3	1.16	0.28	1737	<0.001	0.74	0.640
	(86.0-108.5)	(91.5-114.9)	(99.0-133.4)	(103.6-128.1)	(111.2-133.3)	(113.3-140.6)	(119.8-150.1)	(126.9-151.9)						
Weight, kg	14.5±1.4	15.9±1.3	18.1±1.7	20.0±1.7	22.6±2.3	26.0±3.0	29.1±3.2	32.6±3.4	22.6	<0.001	1898	<0.001	1.36	0.22
	(11.6-17.7)	(12.6-20.0)	(14.1-26.3)	(15.9-25.3)	(18.6-28.8)	(20.1-32.7)	(23.2-36.5)	(26.6-39.8)						
Body Mass Index, kg/m^2	15.5±0.3	15.3±0.4	15.2±0.5	15.2±0.6	15.6±0.5	16.1±0.8	16.4±0.8	16.9±0.8	72.1	<0.001	270.1	<0.001	6.86	<0.001
	(15.0-16.2)	(14.6-16.1)	(14.4-16.1)	(14.4-16.3)	(14.7-16.5)	(14.8-17.5)	(15.3-17.9)	(15.7-18.5)						
Total Body Water, kg	8.56±1.22	9.61±1.14	11.05±1.31	12.13±1.32	13.34±1.62	15.43±1.81	16.92±1.96	18.69±2.29	57.0	<0.001	1053	<0.001	0.81	0.58
	(5.64-11.44)	(7.19-13.5)	(8.16-18.66)	(8.93-16.81)	(10.52-18.61)	(11.72-20.87)	(12.60-21.83)	(14.00-23.90)						
Fat-Free Mass, kg	11.06±1.57	12.44±1.47	14.33±1.70	15.76±1.72	17.35±2.11	20.09±2.35	22.10±2.56	24.43±3.00	114	<0.001	1112.9	<0.001	1.92	0.06
	(7.30-14.80)	(9.30-17.40)	(10.60-24.20)	(11.6-21.8)	(13.70-24.20)	(15.30-27.20)	(16.40-28.50)	(18.30-31.20)						
Fat-Free Mass, %	76.4±6.4	76.7±6.2	77.2±6.5	76.1±6.6	77.5±5.2	77.0±4.8	75.7±4.8	77.8±6.8	110	<0.001	7.87	<0.001	3.33	0
	61.4-92.4)	(63.4-94.5)	(63.0-95.3)	(57.2-95.2)	(65.7-88.5)	(66.9-85.3)	(63.9-84.3)	(61.9-95.5)						
Fat Mass, kg	3.40±0.88	3.46±0.99	3.75±1.19	4.22±1.34	5.25±1.15	5.92±1.76	7.01±1.95	8.13±1.89	78.2	<0.001	315.2	<0.001	1.71	0.1
	(0.70-5.36)	(0.90-6.00)	(0.85-6.92)	(1.00-7.76)	(2.82-8.26)	(2.64-11.10)	(3.7-13.6)	(4.82-12.54)						
Fat Mass, %	23.6±6.4	23.3±6.2	22.8±6.5	23.9±6.6	22.5±5.2	23.0±4.8	24.3±4.8	22.2±6.8	110	<0.001	7.87	<0.001	3.33	0
	(7.7-38.6)	(5.5-36.6)	(4.7-37.0)	(4.8-42.8)	(11.5-34.3)	(14.7-33.1)	(15.7-36.1)	(4.6-38.1)						
FFMI, kg/m^2	11.83±1.02	11.97±0.95	12.03±0.96	12.03±0.97	11.96±0.77	12.43±0.83	12.45±0.88	12.66±1.00	189	<0.001	21.5	<0.001	2.18	0.03
	(9.30-15.22)	(9.80-15.08)	(9.64-14.69)	(10.09-15.36)	(10.84-14.01)	(10.58-14.45)	(10.45-15.38)	(10.6-15.3)						
FMI, kg/m^2	3.68±0.99	3.34±0.95	3.15±0.96	3.22±0.96	3.62±0.73	3.65±0.96	3.93±0.96	4.21±0.89	76.3	<0.001	41.1	<0.001	1.23	0.28
	(0.72-5.81)	(0.85-5.81)	(0.82-5.60)	(0.79-5.89)	(1.71-5.31)	(1.82-5.86)	(2.18-6.65)	(2.62-6.00)						

Mean±Standard Diviation, In parenthesis (Minimum value-Maximum value)

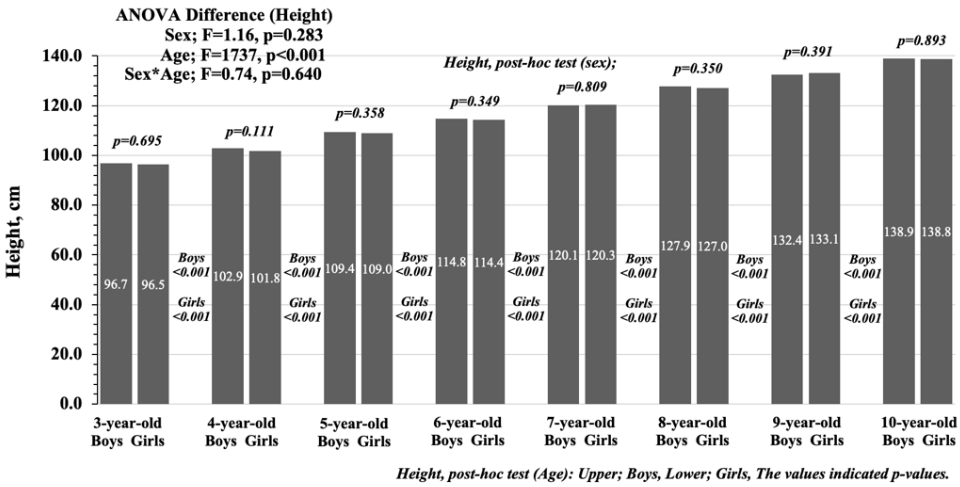

Figure 1: The figure shows age-related changes in the height of standard Japanese children.

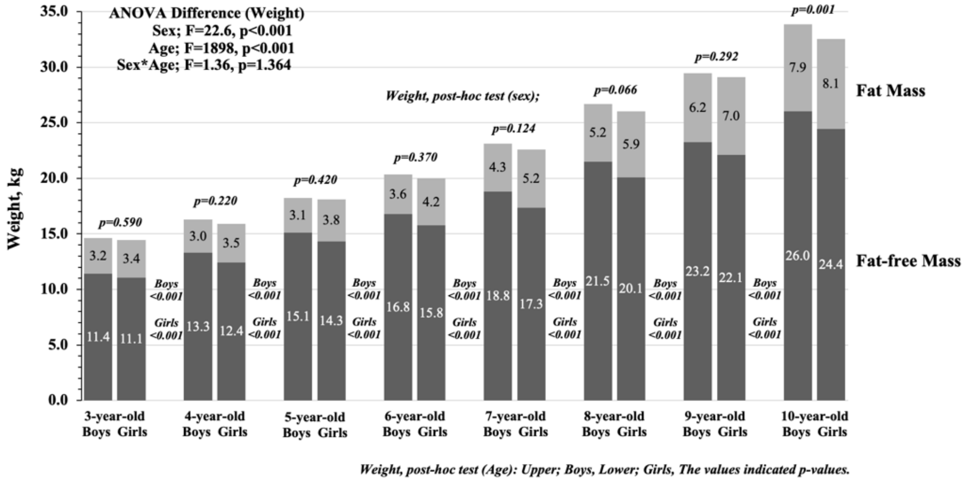

Figure 2: The figure shows age-related changes in the weight of standard Japanese children.

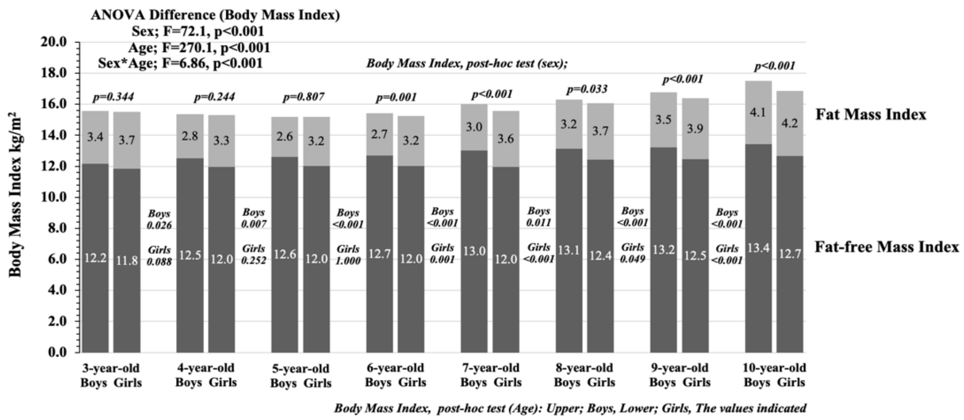

Figure 3: The figure shows age-related changes in the body mass index of standard Japanese children.

early childhood. These features were more pronounced when expressed in terms of quantity (kg), but the comparable result was obtained when expressed as an index (kg/m^2).

4. Discussion

This study provided reference data for the body composition of Japanese children using BMI percentiles. It is important to note that this study was conducted on a large sample of subjects and that the distribution was calibrated by Cole's method. Furthermore, subjects were selected as children with a standard body shape ranging from the 25th to 75th percentile of BMI. After statistically correcting the distribution skewness of the large sample using the LMS method and excluding the

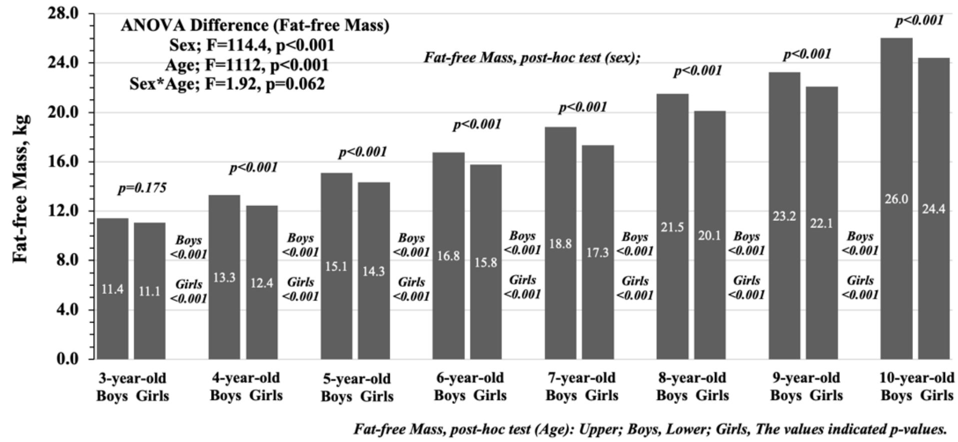

Figure 4: The figure shows age-related changes in the fat-free mass of standard Japanese children. Only component fat-free mass of the weight in Figure 2 was illustrated separately in the figure.

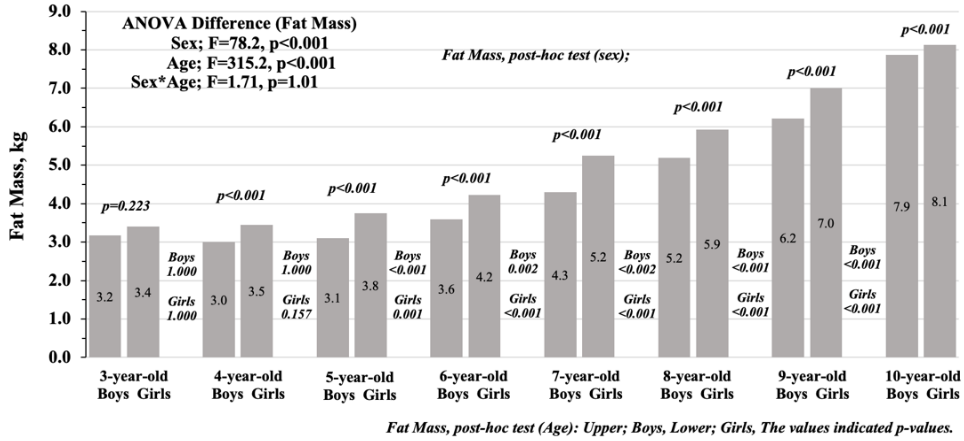

Figure 5: The figure shows age-related changes in the fat mass of standard Japanese children. Only component fat mass of the weight in Figure 2 was illustrated separately in the figure.

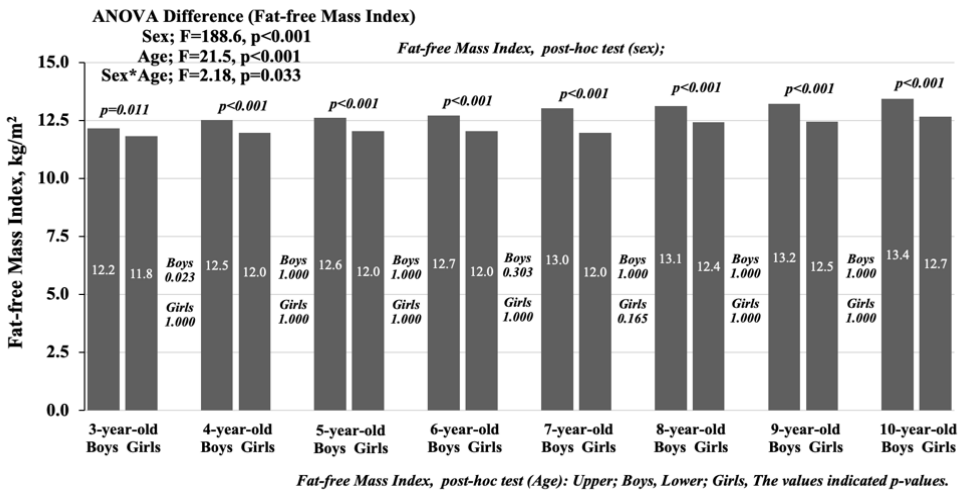

Figure 6: The figure shows age-related changes in the fat-free mass index of standard Japanese children. Only component fat-free mass index of the body mass index in Figure 3 was illustrated separately in the figure.

upper and lower percentile values, we believe that the data in this study were suitable to be treated as standard data in the population. We also believe that these data are important because no previous large-scale studies have provided information on body composition in Japanese children. Furthermore, this study provided the current reference values for body composition as indices of developmental status in Japanese children using the two-component model which has been widely applied for studying body composition in humans. Because standard values for children in Japan have been based on standard weight values for gender,

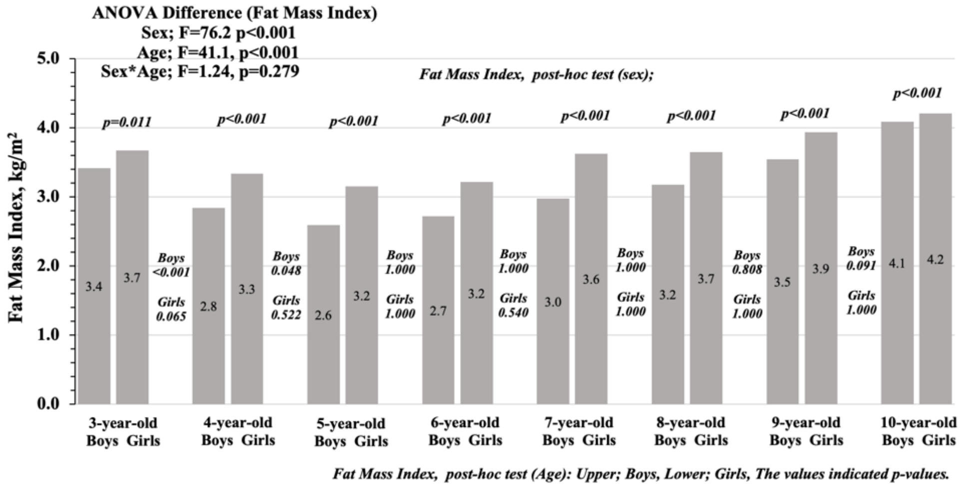

Figure 7: The figure shows the age-related changes in the fat mass index of standard Japanese children. Only component fat mass index of the body mass index in Figure 3 was illustrated separately in the figure.

age, and height, the need to obtain domestic data is still felt because the reference data based on BMI have been used internationally for determining overweightness and obesity.

There exist some clear differences between the results of this study and those of the studies on Chinese children (27) and Asian Indian children (28), The data for Chinese 7-year-old boys (number=105) were height=124.5 cm, weight=27.7 kg, BMI=17.8 kg/m^2, FFMI=13.6 kg/m^2, and FMI=4.2 kg/m^2, and those for Asian Indian 7-year-old boys (number=120) were height=124.5 cm, weight=25.2 kg, FFM=21.0 kg, and FM=4.4 kg, whereas the corresponding data for Japanese 7-year-old boys were height=120.1 cm, weight=23.1 kg, BMI=16.0 kg/m^2, FFM=18.8 kg, FM=4.3 kg, FFMI=13.0 kg/m^2, and FMI=3.0 kg/m^2. The values related to Japanese children were clearly smaller than those for Chinese and Asian Indian children, which was also true for girls. Similarly, for American Indian children (29) and American Indian 7-year-old boys (number: not mentioned), the values were BMI=17.9 kg/m^2 and fat mass=26.6%, while Japanese 7-year-old boys had a fat mass of 19.1%. Conversely, in a study on Iranian children using dual-energy X-ray absorptiometry (DEXA) (30), the data for Iranian 9-year-old boys (number=11) were height=131.2 cm, weight=26.0 kg, BMI=15.0 kg/m^2, FFMI=12.5 kg/m^2, and FMI=2.8 kg/m^2, whereas the corresponding values for Japanese 9-year-old boys were height=132.4 cm, weight=29.5 kg, BMI=16.8 kg/m^2, FFMI=13.2 kg/m^2, and FMI=3.6 kg/m^2. Accordingly, the values for Japanese children were higher than those for Iranian children. Because few previous studies obtained data by age, the data in this study were not sufficiently comparable.

On the other hand, in a study on Japanese children (n=13), using DEXA (30), the data for 5-year-old boys were height=110.0 cm, weight=19.0 kg, BMI=15.7 kg/m^2, FFM=16.4 kg, and FM=2.7 kg, compared with the present data for height=109.4 cm, weight=18.2 kg, BMI=15.2 kg/m^2, FFM=15.1 kg, and FM=3.1 kg. Although these data were derived from children with similar body sizes, there was a slight inversion in the values of FFM and FM. Data for 5-year-old girls (n=11) (31) were height=113.0 cm, weight=19.7 kg, BMI=15.3 kg/m^2, FFM=17.4 kg, and FM=2.3 kg, and the corresponding data for girls in the present study were height=109.0 cm, weight=18.1 kg, BMI=15.2 kg/m^2, FFM=14.3 kg, and FM=3.8 kg. The study of Turumi and colleagues (31) showed higher FFM values in girls than in boys, while the opposite was true for FM, and the trend was reversed in the present study. Some previous studies (32, 33) have indicated higher FM in girls than in boys from early childhood, and our present study showed a similar trend. Furthermore, in a study by Masuda (34), the data for 5-year-old boys (n=127) were height=112.0 cm, weight=19.1 kg, BMI=15.1 kg/m^2, FFM=15.6 kg, and FM=3.4 kg, and those for girls (n=127) were height=111.0 cm, weight=18.3 kg, BMI=14.8 kg/m^2, FFM=14.3 kg, and FM=4.0 kg. These values were comparable to those of the present study. Although some body composition data have been presented for Japanese children, most studies had a small number of subjects and a limited or combined age group. We are convinced that the body composition data obtained in this study are valid because they are comparable to the standard values for the height and weight of Japanese children (26, 35).

The improvements in economic conditions during the last few decades have facilitated full availability of food, thereby allowing changes in dietary composition and contributing to not only accelerated growth in height and weight, but also disproportional development of body composition, resulting in overweightness and obesity (36). The prevalence of obesity is increasing worldwide, even among Asians, and the proportion of the population with major chronic diseases is also increasing substantially (37). This means that research on children needs to be based on race and country-specific reference data for body composition as well as height and weight. However, there were some limitations to this study. Since it was based on about 10 years of data, some generation differences might have been included. In addition, although there were no significant differences in terms of family income, some regional and seasonal differences might have affected the data, as the measurements were conducted in several regions. In the future, based on the data obtained from this study, it will be necessary to study age- and sex-related patterns of change regarding both body shape and body composition in Japanese children. We anticipate that the present data will serve as a basis for further research on the growth and development of Japanese children as well as preventive medicine.

5. Conclusion

This study attempted to establish the standard values of body composition for Japanese pre-school and post-school-age children in relation to age and gender based on subjects from a large data set. We are confident that the body composition data we have obtained are valid because the study subjects represented a large data set and BMI percentile values were used to select normative subjects. Therefore, we anticipate that the data obtained in this study will provide a basis for further investigations in Japanese children.

Ethical Approval

This study was conducted in compliance with the Declaration of Helsinki, the Ethical Guidelines for Clinical Research, and the Act on the Protection of Personal Information. Furthermore, this study received ethical approval from the Research Ethics Committee, Aichi University of Education, Japan. Before the measurements, the children's parents provided informed consent, which was confirmed through kindergarten or after school children's center.

Founding

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