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Hand-Grip Strength and Standing Long Jump of Japanese Children of Two Different Cohorts in Relation to Their Body Composition

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日本人児童の握力，立幅とびと体組成との関連における年代差

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この研究は，握力と立幅とびにおける年代差を体組成との関連から考察している。資料は九州大学発育研究に参加した福岡市生まれの男女児童の人体計測値と運動能力測定値から得られている。男子児童664人，女子児童796人は，1946年生まれと1962年生まれの2集団に分けられている。身長，体重の計測と握力，立幅とびの測定は，各集団とも9歳から14歳までの1956-60年と1971-76年に実施されている。体水分量と除脂肪体重は Mellits らと Pace-Rathbun の方法によって推定され，体脂肪量は体重－(体水分量/0.72) の式によって計算されている。

結果は次のように要約できる。

1　近年の日本人児童は15年前の児童に比較して，体重1 kgあたりの体脂肪量が増加し，除脂肪体重が減少している。

2　男子児童の除脂肪体重1 kgあたりの握力と立幅とびには年代差が認められない。

3　女子児童の体重1 kgあたりと除脂肪体重1 kgあたりの立幅とびには年代差が認められ，近年の女子児童が15年前の児童より劣っている。立幅とびにおける近年の女子児童の劣位は体重1 kgあたりの大きな体脂肪量と小さな除脂肪体重に帰するようである。

ABSTRACT

Secular trends of hand-grip strength and standing long jump of Japanese children were studied in relation to their body composition. The materials for the present study were obtained from serial anthropometric and physical performance measurements on boys and girls, who were Fukuoka city-born participants in the Kyushu University Longitudinal Growth Study. A total materials of 664 boys and 796 girls from the age of 9 to 14 were divided into two cohorts, the one consisting of individuals born in 1946 and the other those born in 1962. Height, body weight, hand-grip strength and standing long jump measurements on children from 9 to 14 year-old were carried out covering the periods, 1956-60 and 1971-76. Total body water (TW) and lean body weight (LBW) were estimated according to the method of Mellits et al. and the formula of Pace-Rathbun, respectively. Body fat (Fat) was calculated according to the equation : Fat=WT-(TW/0.72). The results showed that modern Japanese children contain more Fat and less LBW per unit body weight than those of 15 years ago. The secular differences in hand-grip strength and standing long jump per LBW of Japanese boys were found not significant.

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On the other hand, modern Japanese girls showed lower standing long jump per body weight and LBW than those of 15 years ago. The inferiority of modern Japanese girls in standing long jump could be ascribed to large Fat and small LBW per unit body weight. This might result from their two characteristics, i.e., excessive caloric intake and inactivity.

With our growing awareness of the fact that excessive caloric intake and reduced activity result in overweight and accelerated degenerative changes, we have increasingly been interested in their relation to physical performance.

The secular changes in height and body weight of Japanese children have been observed by several reporters (Kimura, 1967[5] : Komiya et al., 1973[7], 1975[9] : Meredith, 1976[13]). The increase in mean valves of body weight and height of modern Japanese children is more notable than that of several years ago. On the other hand, it has been pointed out that modern Japanese children are inferior in the various kinds of physical performances to those of several years ago (Komiya et al., 1974[8], 1975[9], : and others) .

Recently, we have shown that the secular difference in lean body weight per unit body weight is not significant for boys, but modern Japanese girls have large body fat and small lean body weight per unit body weight (Komiya and Kikkawa, 1979[10]). Similarly, the body fat - body weight relation has shown that body fat of modern Japanese children increases at a faster relative rate than that of those of 16 years ago (Komiya and Kikkawa, 1979[10]).

Sills and Everett have shown that significantly lower scores of endomorphs in 50 yard dash and 200 yard run could be ascribed to greater body weight with more fat (Siils and Everett, 1953[16]). Kitagawa and Miyashita have also shown that obese men have lower muscle strength per body weight and lean body mass than non-obese men (Kitagawa and Miyashita, 1978[6]).

These findings provided us a basis for interpreting the inferiority of modern Japanese in physical performance which is known to exist both is childhood and adolescence.

Until recently, an analysis of the relationship between body composition and physical performance of Japanese has been limited to the derivation of variables that contain various informations, e.g., absolute lean body weight and body fat, lean body weight and body fat per kg of body weight, and their comparison among different cohorts.

The purpose of the present study is to compare hand-grip strength and standing long jump of modern Japanese children with those of 15 years ago in relation to their body composition.

MATERIALS AND METHODS

The materials for the present study were obtained from serial anthropometric and physical performance measurements on boys and girls, who were Fukuoka city-born participants in the Kyushu University Longitudinal Growth Study.

Height, body weight, hand-grip strength and standing long jump measurements on children from the age of 9 to 14 were carried out covering the periods 1956-60 and 1971-76. Hand-grip strength was measured by a Smedley type hand dynamometer and was recorded as the average of bilateral strength. The best of the two trials in standing long jump was recorded.

Total body water (TW) , in liters, was estimated from body weight and height according to the revised formula of Mellits and Cheek (1970[12]). Body water was assumed to be constant,

i.e., 72 per cent of lean body weight (LBW) for a normal human (Behnke, 1963[2] : Pace and Rathbun, 1945[15]).

Therefore, LBW, in kilograms, was estimated from TW according to the formula of Pace-Rathbun : LBW=TW/0.72.

Body fat (Fat), in kilograms, was indirectly calculated according to the equation : Fat=WT-(TW/0.72).

The above equations were derived on the basis of the fact that lean tissue has 72 per cent water and a body consists of water, lean tissue solids and fat.

A total materials of 664 boys and 796 girls from 9 to 14 years old were divided into two cohorts ;the one consisting of individuals born in 1946 and the other those born in 1962. Anthropometric values were related to corresponding functional ones.

For mathematical and statistical evaluation, the arithmetic mean, standard deviation, *t*-test, correlation, regression and K value calculations were assessed.

RESULTS

Mean values of various physical characteristics of both cohorts are given in Table 1. All differences between the two cohorts were significant at the 0.01 level except for height, body weight and LBW of boys. Of all significant differences, only LBW per unit body weight in the cohort 1971-76 showed lower value than that of the cohort 1956-60. Consequently, modern Japanese children have large Fat and small LBW per unit body weight than those of 15 years ago.

Mean values of hand-grip strength and standing long jump are also shown in Table 1. The t-test for boys did not show statistically significant differences in hand-grip strength and standing long jump between the two cohorts. The test of hand-grip strength of girls showed significant difference between the two cohorts, showing lower value for the cohort 1956-60. But girls of the cohort 1971-76 showed lower value in the exerted standing long jump than those of the cohort 1956-60. Furthermore, the lower values of the girls of the cohort 1971-76 were also found in standing long jump per body weight and LBW.

The relationship between body compositions and physical performances in the two cohorts were also examined, as described below.

Table 1.
Mean Values of Physical Characteristics, Hand-Grip Strength and Standing Long Jump of Japanese Children of Cohorts 1956-60 and 1971-76.

	Boys					Girls				
	Cohort 1956-60 Sample Size 307		Cohort 1971-76 Sample Size 357		Sig. Diff.	Cohort 1956-60 Sample Size 389		Cohort 1971-76 Sample Size 407		Sig. Diff.
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Height(cm)	143.9	11.14	143.6	12.39		142.4	9.73	146.0	10.32	**
Body Weight(kg)	34.9	8.15	36.0	9.60		34.5	7.68	38.8	9.48	**
Lean Body Weight(kg)	31.0	7.59	31.6	8.53		28.2	4.65	30.5	5.25	**
Lean Body Weight(kg)/Body Weight(kg)	0.884	0.028	0.876	0.038	**	0.827	0.058	0.799	0.067	**
Fat(kg)	3.9	1.11	4.4	1.95	**	6.2	3.27	8.3	4.60	**
Fat(kg)/Body Weight(kg)	0.113	0.028	0.122	0.038	**	0.170	0.056	0.198	0.066	**
Hand-Grip Strength(kg)	23.1	6.92	24.3	8.53		20.5	5.19	22.5	6.08	**
Hand-Grip Strength(kg)/Body Weight(kg)	0.658	0.087	0.667	0.118		0.594	0.084	0.585	0.100	
Hand-Grip Strength(kg)/LBW(kg)	0.743	0.099	0.759	0.119		0.720	0.104	0.732	0.120	
Standing Long Jump(cm)	175.3	22.23	175.1	25.96		162.3	16.02	152.6	18.61	**
Standing Long Jump(cm)/Body Weight(kg)	5.167	0.825	5.055	0.930		4.915	1.058	4.141	0.989	**
Standing Long Jump(cm)/LBW(kg)	5.849	0.995	5.765	1.058		5.890	0.971	5.125	0.904	**

** $p<0.01$

The regression equations, with logarithms of hand-grip strength and standing long jump as dependent variables, and corresponding coefficients of correlation (r) are given in Table 2. Regression equations were calculated from cohort means and standard deviations according to the reduced major axis method (Imbrie, 1956[3] : Kermack and Haldane, 1950[4]). The correlation between standing long jump and Fat for boys of the cohort 1971-76 was found to be lower (r= .021) as compared to other correlations.

Table 2.
Regression Equations, Corresponding Coefficients of Correlation and Differences in Regression Slopes and Intercepts Between Two Cohorts.

	Cohort	Sample Size	Correlation(r)	Regression Equation	Difference Between Slopes(K)	Difference Between Intercepts(K)
Log Hand-Grip Strength(Y)-Log Lean Body Weight(X)						
Boys	1956-60	307	.881	Y=1.2047X-0.4347	K=2.655 **	K=51.000 **
	1971-76	357	.901	Y=1.3202X-0.6004		
Girls	1956-60	389	.856	Y=1.6075X-1.0252	NS	K=10.538 **
	1971-76	407	.837	Y=1.6272X-1.0673		
Log Standing Long Jump(Y)-Log Lean Body Weight(X)						
Boys	1956-60	307	.727	Y=0.5301X+1.4560	NS	K=53.000 **
	1971-76	357	.723	Y=0.5573X+1.4105		
Girls	1956-60	389	.326	Y=0.5899X+1.3562	K=2.434 *	K=50.800 **
	1971-76	407	.357	Y=0.6902X+1.1606		
Log Hand-Grip Strength(Y)-Log Fat(X)						
Boys	1956-60	307	.382	Y=1.0039X+0.7688	K=3.030 **	K= 9.250 **
	1971-76	357	.200	Y=0.8030X+0.8734		
Girls	1956-60	389	.750	Y=0.4633X+0.9574	NS	K= 8.500 **
	1971-76	407	.685	Y=0.4867X+0.9233		
Log Standing Long Jump(Y)-Log Fat(X)						
Boys	1956-60	307	.218	Y=0.4417X+1.9856	K=3.423 **	K=24.200 **
	1971-76	357	.021	Y=0.3309X+2.0326		
Girls	1956-60	389	.263	Y=0.1700X+2.0838	K=2.983 **	K=47.454 **
	1971-76	407	.240	Y=0.2064X+2.0050		

* p<0.05, ** p<0.01
K values were calculated according to the formula of Imbrie (1956).

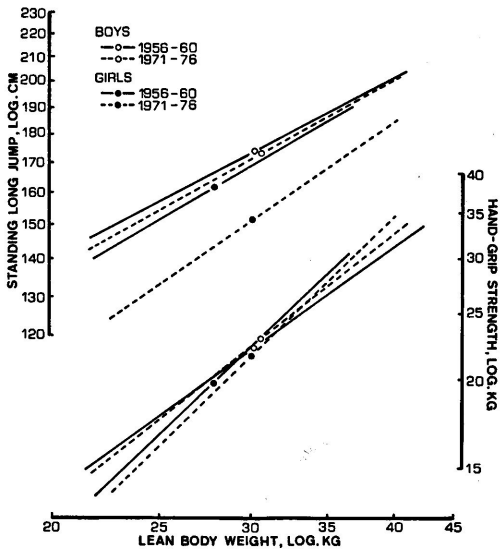

Fig. 1. Comparison of regression lines between two cohorts.

The significant differences in regression slope and intercepts between the two cohorts are also seen in Table 2. All K values showed that intercept differences in regression lines between the two cohorts were statistically significant.

An analysis of covariance was used to test whether slopes and intercepts of regression lines for LBW versus hand-grip strength or standing long jump are different between the two cohorts. Figure 1 was constructed by plotting the regressions listed in Table 2. The hand-grip strength/LBW trend lines for girls were parallel :the mean relative increments in hand-grip strength per unit increment in LBW were identical between the two cohorts. On the other hand, the corresponding trend lines for boys of the cohort 1971-76 were distinctly steeper than that of the cohort 1956-60. The slope difference of the standing long jump/LBW lines for boys was not statistically significant between the two cohorts. The slopes of the corresponding trend line for girls showed a significant difference between the two cohorts, lower in cohort 1956-60 and higher in cohort 1971-76. However, all calculated K values showed that intercept

Table 3.
Multiple Regression Equations, Standard Partial Regression Coefficients (β_1,β_2) and Partial Correlation Coefficients ($r_{YX_1 \cdot X_2}$, $r_{YX_2 \cdot X_1}$).

	Cohort	Sample Size	Multiple Correlation (r)	Multiple Regression Equation	Standard Partial Regression Coefficient X_1 with Y(β_1)	Standard Partial Regression Coefficient X_2 with Y(β_2)	Partial Correlation X_1 with Y ($r_{YX_1 \cdot X_2}$)	Partial Correlation X_2 with Y ($r_{YX_2 \cdot X_1}$)
Hand-Grip Strength(Y)-Lean Body Weight(X_1),Fat(X_2)								
Boys	1956-60	307	.890**	$Y=0.763X_1+0.671X_2-3.150$	.837	.108	.854**	.209**
	1971-76	357	.919**	$Y=0.989X_1-0.793X_2-3.499$	.989	-.181	.912**	-.375**
Girls	1956-60	389	.863**	$Y=0.970X_1-0.009X_2-6.817$	.868	-.006	.630**	-.004
	1971-76	407	.844**	$Y=1.153X_1-0.243X_2-10.582$	.995	-.184	.876**	-.171**
Standing Long Jump(Y)-Lean Body Weight(X_1),Fat(X_2)								
Boys	1956-60	307	.744**	$Y=2.264X_1-1.439X_2+110.654$	.773	-.072	.721**	-.094
	1971-76	357	.810**	$Y=2.781X_1-4.936X_2+108.808$	.914	-.371	.809**	-.488**
Girls	1956-60	389	.359**	$Y=2.161X_1-1.692X_2+112.052$	.627	-.345	.301**	-.169**
	1971-76	407	.419**	$Y=2.441X_1-1.504X_2+90.721$	.688	-.371	.369**	-.111 *

* p<0.05, ** p<0.01

Table 4.
Mean Values of Hand-Grip Strength and Standing Long Jump for the Grouping of LBW Per Cent Body Weight Category.

	Number Observed Cohort 1956-60	Number Observed Cohort 1971-76	Hand-Grip Strength(kg) Cohort 1956-60 Mean	Hand-Grip Strength(kg) Cohort 1956-60 SD	Hand-Grip Strength(kg) Cohort 1971-76 Mean	Hand-Grip Strength(kg) Cohort 1971-76 SD	Sig. Diff. (t)	Standing Long Jump(cm) Cohort 1956-60 Mean	Standing Long Jump(cm) Cohort 1956-60 SD	Standing Long Jump(cm) Cohort 1971-76 Mean	Standing Long Jump(cm) Cohort 1971-76 SD	Sig. Diff. (t)
Boys												
%LBW												
75.1-80.0	0	10			22.5	6.48				152.3	19.20	
80.1-85.0	32	67	19.8	5.95	20.5	6.85		161.5	18.83	160.8	16.70	
85.1-90.0	180	182	22.4	7.02	23.2	8.91		172.3	20.78	172.7	25.17	
90.1-95.0	92	89	25.6	6.35	29.0	7.01	**	185.3	21.93	191.0	24.88	
95.1 and over	3	9	26.0	3.46	29.3	5.78		193.3	25.32	197.0	16.97	
Girls												
%LBW												
Up to & incl.70.0	4	29	24.7	6.70	27.3	5.38		157.7	6.50	149.7	20.52	
70.1-75.0	38	64	26.0	3.42	27.5	4.61		163.0	14.64	161.7	20.32	
75.1-80.0	86	102	24.2	3.54	24.8	4.60		167.5	17.42	156.8	19.14	**
80.1-85.0	114	116	20.9	4.26	20.7	5.24		164.2	16.47	149.2	16.86	**
85.1-90.0	110	70	16.8	3.42	17.9	4.83		158.7	13.94	147.8	16.19	**
90.1 and over	37	26	15.1	3.71	16.5	3.80		155.3	14.74	145.7	11.84	**

** p<0.01

differences of regression lines between two the cohorts were statistically significant. Namely, the lower values of the cohort 1971-76 were found in standing long jump per unit LBW and this trend was more particular for girls.

In order to make clear the relationship between LBW and hand-grip strength or standing long jump, the effect of Fat on physical performance was investigated, as described below.

Multiple regression equations for hand-grip strength (Y) or standing long jump (Y) versus LBW (X_1) and Fat (X_2) are presented in Table 3. Multiple correlation coefficients (R) , standard partial regression coefficients (β_1, β_2) and partial correlation coefficients ($r_{yx_1 \cdot x_2}$, $r_{yx_2 \cdot x_1}$) are also shown in the same table. All partial correlation coefficients with Fat (X_2) held constant were significantly and positively correlated with hand-grip strength and standing long jump, respectively. Inversely, all partial correlation coefficients with LBW (X_1) held constant were correlated negatively with hand-grip strength and standing long jump, except for boys of the cohort 1956-60. We see from standard partial regression coefficient and partial correlation coefficient that only hand-grip strength of boys does show cohort difference.

The hand-grip strength and standing long jump are shown for the grouping of LBW per cent body weight category in Table 4. The *t*-test for boys did not show statistically significant differences in hand-grip strength and standing long jump between the two cohorts, except for the group of 90.1-95.0%LBW. Similar results were also obtained from the hand-grip strength of girls.

Table 5.
Mean Values of Hand-Grip Strength and Standing Long Jump for Grouping of Fat Per Cent Body Weight Category.

	Number Observed		Hand-Grip Strength (kg)				Standing Long Jump (cm)			
	Cohort 1956-60	Cohort 1971-76	Cohort 1956-60 Mean	SD	Cohort 1971-76 Mean	SD	Sig. Diff. (t)	Cohort 1956-60 Mean	SD	Cohort 1971-76 Mean	SD	Sig. Diff. (t)
Boys												
%Fat												
Up to & incl. 6.0	11	17	27.2	5.96	28.8	5.88		192.0	28.36	192.5	14.95	
6.1- 8.0	29	32	25.8	5.97	30.4	7.18	*	183.3	22.82	196.5	27.64	
8.1-10.0	61	56	25.2	6.31	27.9	6.74	*	184.8	19.80	185.3	24.09	
10.1-12.0	66	65	24.7	7.09	26.7	9.08		180.6	20.35	185.0	25.79	
12.1-14.0	86	72	21.6	6.70	21.6	9.15		167.4	19.85	168.4	25.21	
14.1-16.0	42	68	18.5	5.00	19.2	5.75		163.1	17.13	159.4	14.74	
16.1 and over	12	47	21.8	8.90	22.2	7.67		162.2	24.88	161.1	19.49	
Girls												
%Fat												
Up to & incl. 8.0	19	9	14.7	3.72	14.7	2.58		152.3	14.39	140.0	10.25	*
8.1-12.0	57	47	16.1	3.57	17.6	4.23		157.4	13.58	146.9	13.06	**
12.1-16.0	102	64	17.8	3.66	19.0	5.10		160.6	15.27	151.9	17.31	**
16.1-20.0	90	93	21.5	4.43	20.9	5.43		164.6	15.95	147.5	16.64	**
20.1-24.0	71	81	24.3	3.64	24.5	4.55		168.4	18.18	156.2	19.04	**
24.1-28.0	44	70	25.7	3.21	26.8	4.58		163.0	14.49	160.3	20.68	
28.1 and over	6	43	26.0	4.77	27.6	5.34		159.1	9.26	154.8	20.80	

* $p<0.05$, ** $p<0.01$

It is seen from this table that standing long jump of girls tends to decrease with increasing % LBW. Furthermore, the values of the cohort 1971-76 appear to be significantly low against that of the cohort 1956-60. The exerted hand-grip strength and standing long jump are shown in Table 5 in order of %Fat. Standing long jump of girls showed significant differences between the two cohorts indicating lower values for the cohort 1971-76. The lower values in standing long jump of high %Fat groups are also found in the cohort 1971-76, but the difference was not significant.

DISCUSSION

The secular trend of larger body size and earlier maturation of man has long been recognized (Meredith, 1976[13] : Moore, 1970[14] : Tanner, 1962[17]). We have shown that the secular difference in LBW per unit body weight is not significant for boys, while modern Japanese girls have large Fat and small LBW per unit body weight (Komiya and Kikkawa, 1979[10]).

Some studies have been made on the relationship between body composition and physical performance of obese or old men (Kitagawa and Miyashita, 1978[6] :Kuta et al., 1970[11]). However, there has been little information about the secular trend of the relation between body composition and physical performance of Japanese children.

Hand-grip strength shows higher values of modern Japanese children of both sexes. Modern Japanese girls do show significantly lower values in standing long jump. Similar results are obtained from standing long jump per unit body weight and per unit LBW. These significantly lower values may result from their greater body weight and smaller LBW per kg of body weight. This means that modern Japanese girls find it difficult to move their body weight as a load quickly. Greater body weight of modern Japanese girls could be ascribed to their large Fat. This may result from their two characteristics, i. e., excessive caloric intake and reduced activity.

LBW should be considered to be proportional to muscle mass (Behnke et al., 1953[1] : Kuta et al., 1970[11]). But, Kitagawa and Miyashita have shown that muscle strength per LBW of obese men appears to be lower than non-obese men (Kitagawa and Miyashita, 1978[6]). Our results nearly agrees with theirs for obese men.

Similar results are also obtained by an analysis of covariance. The present study shows that standing long jump per LBW of modern Japanese children appears to be lower than that of Japanese children of 15 years ago and this trend is more notable for girls.

In order to make clear the relationship between LBW and hand-grip strength or standing long jump, the effect of Fat on physical performance was investigated. The essential relationship of body composition to physical performance is identical, in the two different cohorts. Therefore, because of the combined effects of more Fat and less LBW per unit body weight, standing long jump of modern Japanese shows lower value than those of 15 years ago.

The comparison of the same LBW and Fat per cent body weight categories shows that standing long jump of modern Japanese girls appears to be lower for all categories. It must be further investigated why modern Japanese children show lower value in standing long jump in spite of the same LBW per cent body weight.

Finally, it should be confirmed that modern Japanese children contain more Fat and less LBW per unit body weight than those of 15 years ago. On the other hand, the secular differences in hand-grip strength and standing long jump per LBW of Japanese boys are found not significant. Our conclusion is that modern Japanese girls show lower standing long jump per unit body weight and LBW than those of 15 years ago. The inferiority of modern Japanese girls in standing long jump could be ascribed to large Fat and small LBW per unit body weight. In our highly industrialized and automated society, overweight is closely related to inactivity and overnutrition. Therefore, the inferiority in standing long jump may be resulted from their two characteristics, i.e., excessive caloric intake and inactivity.

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