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Body Proportions of Han and Pai-wan School Children in Pingtung

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ABSTRACT: Objective: There are significant racial differences in body proportions. Such data are not readily available for Taiwanese children. This paper is conducted with the analysis of the difference in body proportions for boys and girls in the Pingtung County area and comparing them with data of Pai-wan and Han children. A total of 919 Pai-wan and Han children from the first to sixth grade, are recruited randomly from 8 elementary schools in the Pingtung area. **Methods:** Body proportions included the waist/hip circumference ratio, waist circumference/stature ratio, sitting height/stature ratio, stature/arm span ratio, biepicondylar breadth of the humerus/bicondylar breadth of the femur ratio, and the biacromial breadth/biiliac breadth ratio. Statistical analyses included t-test, analysis of covariance and post-hoc comparisons of least square means. **Results and Conclusions:** The waist/hip circumference ratio and the biacromial breadth/biiliac breadth ratio are significantly higher in Pai-wan children than in Han children for boys and girls, respectively. The waist circumference/stature ratio and the sitting height/stature ratio are significantly higher in Pai-wan girls than in Han girls. The biepicondylar breadth of the humerus/bicondylar breadth of the femur ratio in Han boys is significantly higher than that in Pai-wan boys.

Key words: body proportions, Han, Pai-wan, school children

INTRODUCTION

Body size is the reference of the norm for estimating the growth development and nutritional condition of school children. The body proportions deriving from the body size are frequently used as an important basis for judging the health conditions, such as the waist/hip circumference ratio (WHR)[1,2] and waist circumference/stature ratio[3] which could be positive predictors for cardiovascular diseases in adults or children. A variety of variables, including age, gender, nutritional status, and racial differences, cause differences in body proportion[2,4,5]. Among these variables, racial and ethnic differences give the most significant contributions. Studies[6,7] show that the Black people have on average, shorter trunks, longer upper and lower extremities, and more slender hips. Therefore, for the same stature, Blacks have relatively longer extremities than Caucasians, and for the same biacromial breadth, Black people have relatively narrower biiliac breadth than Caucasians. In addition to the sitting height ration (upper segment height) to stature, reports from British and Japanese-Americans[8] show that Japanese-Americans have relatively shorter lower segment height (subischial leg height or stature minus sitting height).

Gender differences in body proportions vary by ratios. The ratio of arm span to standing height is similar for boys and girls[11], but the WHR of boys is higher than that of girls[17]. On the other hand, gender differences in the sitting height ration to stature and the biacromial breadth ration to biiliac breadth vary by age[21]. However, similar data on body proportions for Taiwanese children have been grossly lacking in the past two to three decades, especially for aboriginal children. Some of the early Taiwanese aboriginal studies[9,10] based on the anthropometric measurements and physical development were done nearly 50 years ago. Specific analyses of the various parameters in body proportions, such as the WHR, the waist circumference/stature ratio, the sitting height/stature ratio and the stature/arm span ratio, were not included. Measurements of these ratios are important in anthropologic studies and useful as alternative data in growth situations and health status of aboriginal children. The WHR is positively related to triglycerides[17], and also positively associated with systolic blood pressure[18]. The waist circumference/stature ratio is a better predictor of cardiovascular disease risk factors in children than body mass index[3]. Either the ratio of upper to lower segment height or the ratio of sitting

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height to stature could be used to assess skeletal growth in school children[13-15]. In addition, the ratio of stature to arm span could be the referred norms in which stature cannot be measured directly because of physical deformities involving limb and spinal injuries[11,12]. This study was conducted using analysis of the differences in body proportions for boys and girls in Pingtung and comparing them with data on Pai-wan and Han school children.

MATERIALS AND METHODS

The population distribution in Pingtung is mainly Han, Pai-wan aboriginal and Lu-Kai aboriginal. However, the Pai-wan population is primarily aboriginal. The population for this study was the first to sixth grade children of elementary schools in Pingtung. The focus was on Han and Pai-wan children. There are one hundred and sixty-nine elementary schools in the Pingtung area. These schools could be divided into two parts: schools with a majority of Han children and schools with a majority of Pai-wan children. All of these schools were stratified by race. Han schools were defined as those with more than 90 percent Han children. Pai-wan schools had more than 90 percent Pai-wan children. Due to an insufficiency of research manpower and funds, the authors chose only eight schools. Five schools were randomly selected from the Pai-wan schools and three schools were randomly selected from the Han schools. The sampling unit was one classroom selected from the first and sixth grades of the 8 randomly chosen schools. All of the children in the selected classrooms were research subjects. Approval to administer these measurements was obtained from the school administrators at each selected school.

The anthropometric parameters included stature, sitting height, arm span, biacromial breadth, biiliac breadth, bicondylar breadth of the femur, biepicondylar breadth of the humerus, waist circumference, and hip circumference. The derived variables for body proportions included the waist circumference to hip circumference ratio, the waist circumference to stature ratio, the sitting height to stature ratio, the stature to arm span ratio, the biepicondylar breadth of the humerus to the bicondylar breadth of the femur ratio, and the biacromial breadth to biiliac breadth ratio. Standard measurement techniques for each anthropometric parameter followed the reference manual[15].

Stature was measured with the child standing barefoot on the platform of a portable Harpenden stadiometer with the upper back, buttocks, and heels pressed against the upright portion of the instrument. The subject's head was positioned in the Frankfort horizontal plane, the shoulders relaxed, the back straight, and the head plate was brought into firm contact with the vertex. The sitting height measurement was conducted similar to the stature measurement. The difference was that the subject sat on a table with his/her legs hanging unsupported over the edge of the table and with the hands resting on the thighs. The knees were directed straight ahead. The backs of the knees were near the edge of the table but not in contact with it.

Arm span was measured using a flexible steel tape (the length was approximately two meters) from the tip of the middle finger on one hand to the tip of the middle finger on the other hand with the individual standing straight with his/her back to the wall. The subject's elbows and wrists were extended with the palms facing directly forward. Biacromial breadth was measured with an anthropometer (Model 01290, Lafayette Instrument Company, Indiana) from the rear of the subject. The subject stood straight with the heels together and the arms hanging by the sides. The shoulder region was free of clothes. The subject was instructed to relax with the shoulders downward and slightly forward so that the reading would be maximal. For tall subjects, the measurer stood upon a stool to produce an accurate measurement. Biiliac breadth was also measured with an anthropometer (Model 01290, Lafayette Instrument Company, Indiana) from the rear of the subject. The subject stood with the feet apart nearly 5 cm in order to avoid swaying. The arms were placed away from the area of measurement, preferably folded in front of the chest. The anthropometer blades were brought into contact with the iliac crests so that the maximal breadth was recorded. The anthropometer was applied at a downward angle of 45 degrees with firm pressure.

The bicondylar breadth of the femur was defined as the distance between the most medial and most lateral aspects of the femoral condyles. The legs of the subject were flexed 90 degrees at the knee with the subject sitting on a table. The measurer stood facing the subject. Using an anthropometer (Model 01291, Lafayette Instrument Company, Indiana), the measurer guided the anthropometer blades with the thumb and index finger of each hand, applying the anthropometer diagonally downward and towards the right knee of the subject. The lateral femoral epicondyle was palpated with the middle finger of the left hand while the middle finger of the right hand palpated the medial epicondyle. The biepicondylar breadth measurement of the humerus involved measuring the distance between the epicondyles of the humerus. The subject raises the right arm horizontal and the elbow was flexed to 90 degrees. The back of the subject's hand faced the measurer. The measurer stood in front of the subject and palpated the medial and lateral epicondyles of the humerus. An anthropometer (Model 01291, Lafayette Instrument Company, Indiana) was applied pointing the blades upward to 45 degrees at the elbow. The measurer exerted firm pressure to decrease the influence of soft tissue.

The waist circumference measurement was defined as the narrowest part of the waist. The subject wore light clothing so that the tape could be positioned correctly. The subject stood with the abdomen relaxed, arms at the sides and feet together. The measurement was not made over clothing. The measurer faced the subject and placed an inelastic tape around the waist of the subject, in a horizontal plane, at the level of the natural waist, which is the narrowest part of the torso, as seen from the anterior aspect. The measurement was taken at the end of a normal expiration, without the tape compressing the skin of the waist. The hip circumference measurement was taken the broadest part of the hip. The subject wore light clothing and stood straight with the arms at the sides and feet together. The measurer squatted beside the subject and placed an inelastic tape around the hip in a horizontal plane at this level without compressing the skin of the hip.

The measurements of all parameters were taken to the nearest 0.1cm. The mean of two measurements for each parameter was recorded. The test-retest reliability was undertaken for 26 fourth-grade school children in Pingtung. The reliability coefficients of two days for all parameters were between 0.87~0.96 ($p<0.001$). Statistical analyses included descriptive analysis, t-test, analysis of covariance (ANCOVA), and post-hoc comparisons of least square means.

RESULTS

A total of 919 Pai-wan and Han children from the first to sixth grade, were recruited randomly from 8 elementary schools in the Pingtung area. None had physical abnormalities or known medical or orthopaedic diseases. There were three hundred and twenty-five Han children (35.4%) and five hundred and ninety-four Pai-wan aboriginal children (64.6%). There were four hundred and sixty-nine boys (51.0%) and four hundred and fifty girls (49.0%). The numbers of subjects in the different grades from the first to sixth grade are as follows: first grade-one hundred and thirteen children (12.3%), secong grade-eighty-nine children (9.7%), third grade-one hundred and thirty-one children (14.3%), fourth grade-one hundred and fifty-six children (17.0%), fifth grade-two hundred and ten children (22.9%) and sixth grade-two hundred and twenty children (23.9%). The mean age was 10.03 ± 1.73 years old and the range was from 6.16 to 13.11 years old. Table 1 shows the mean and standard deviations for the anthropometric parameters.

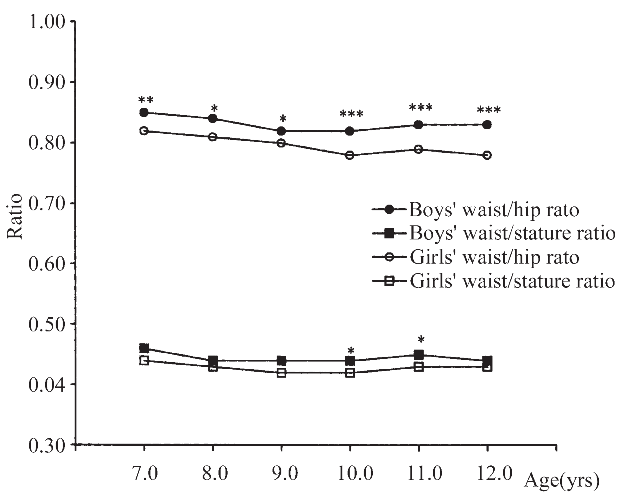
Differences in Body Proportions by Gender and Age

The t-test for the waist to hip circumference and waist circumference to stature ratios by gender and age are shown Figure 1. The waist to hip circumference ratio was significantly higher in boys than in girls at all ages. The t-values were between 2.10 ($p<0.05$) to 6.91 ($p<0.001$). Gender difference in the waist circumference to stature ratio existed only in the ten ($t=2.04$, $p<0.05$) and eleven ($t=2.42$, $p<0.05$) year old groups in which boys were

Table 1 Mean and standard deviation (SD) of anthropometric variables for school children

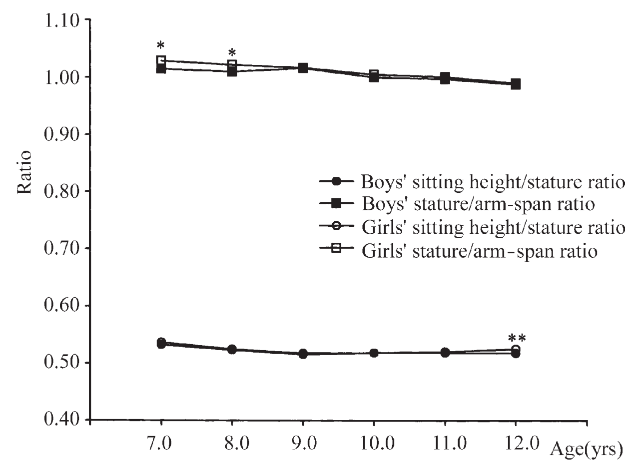
	Boys (n=469)		Girls (n=450)	
Anthropometric variables	Mean	SD	Mean	SD
Stature (cm)	135.03	11.65	136.42	12.81
Sitting height (cm)	70.28	6.09	71.36	6.57
Waist circumference (cm)	59.82	10.81	58.38	8.71
Hip circumference (cm)	71.85	10.78	74.22	16.82
Arm span (cm)	135.09	13.56	135.73	14.43
Biiliac breadth (cm)	21.63	2.50	21.95	2.53
Biepicondylar breadth of humerus (cm)	5.67	0.59	5.41	0.50
Bicondylar breadth of femur (cm)	8.63	0.90	8.31	0.86
Biacromial breadth (cm)	31.52	3.29	31.60	3.36

greater than girls. Figure 2 shows t-test for the sitting height to stature and stature to arm span ratios by gender and age. The sitting height to stature ratio did not differ between the genders at all ages, except at 12 years of age. The ratio for the twelve year old group (t=-3.27, p<0.01) was significantly higher in girls. Gender differences in the stature to arm span ratio occurred only at 7 (t= -2.39, p <0.05) and 8 (t= -2.10, p<0.05) years of age in which girls were greater than boys. Gender differences in the biacromial breadth to biiliac breadth and biepicondylar breadth of the humerus to bicondylar breadth of the femur ratios by age are shown Figure 3. The biacromial breadth to biiliac breadth ratio was significantly higher in boys than in girls at 7 (t=2.87, p<0.01), 11 (t=2.23, p<0.05), and 12 (t=3.01, p<0.01) years of ages. The biepicondylar breadth of the humerus to bicondylar breadth of the femur ratios were significantly higher in boys at 12 years of age (t=2.84, p <0.01) only. There was no difference between the genders at all other ages.



*p<0.05；**p<0.01；***p<0.001

Fig. 1 Waist/hip ratio and waist/stature ratio for school boys and gilrs in Pingtung



*p<0.05；**p<0.01

Fig. 2 Sitting height/stature ratio and stature/arm-span ratio for school boys and gilrs in Pingtung

*p<0.05；**p<0.01

Fig. 3 Biepicondylar of humerus/bicondylar of femur ratio and biacromial/biiliac ratio for school boys and gilrs in Pingtung

Differences in Body Proportions by Gender and Race

To further explore the racial differences in body proportions, both Han and Pai-wan children for each gender were compared. Analyses of covariance was used in order to control for age when comparing the groups. These analyses took the body proportions as dependent variables and the two racial groups for each gender as independent variables. The age was the covariate, and post hoc comparisons of least squares means were performed. Before the analysis of covariance, the homogeneity of within-class regression coefficient was checked to determine whether the slope of each group was the same or not for fitting the hypothesis of homogeneity. The result shows that the within-class homogeneity regression coefficient in all body proportion parameters fit the hypothesis (F=0.39~1.94, P> 0.05). Table 2 shows that the waist/hip circumference and biacromial breadth/biiliac breadth ratios are significantly higher in Pai-wan children than in Han children for boys and girls, respectively. The waist circumference/stature and sitting height/stature ratios are significantly higher in Pai-wan girls than in Han girls. The biepicondylar breadth of humerus/bicondylar breadth of femur ratio in Han boys is significantly higher than that in Pai-wan boys.

DISCUSSION

In general, boys are higher than girls in waist circumference, but boys are lower than girls in hip circumference[16]. The ratio of waist to hip circumference of boys is higher than that of girls[17]. This shows a negative relationship to the HDL cholesterol concentration, but this is also positively associated with the total cholesterol to HDL cholesterol concentration ratio and the systolic pressure in children[2,18]. The WHR of children varies with race. Gillum[2] reported that Mexican American children have a higher WHR than American children. The current study shows that the WHR of boys is higher than that of girls at all ages (Fig. 1). Moreover, Pai-wan children are higher than Han children in the WHR for boys and girls (Table 2). These results are similar to those from a previous study[17]. The waist circumference/stature ratio is a risk factor for cardiovascular diseases in children[3] and adults[5]. Many studies use the WHR/stature ratio as predictors for triglyceride, insulin and alanine aminotransferase in children[19]. This study demonstrated that the waist circumference/stature ratio of boys is higher than that of girls at 10 and 11 years (Fig. 1). In addition, this ratio for Pai-wan girls is higher than that for Han girls after controlling for age (Table 2).

Table 2 Mean (standard error), analysis of covariance in body proportions for boys and girls

Body proportion variables	Boys: Han (n=165)	Boys: Pai-wan (n=304)	Boys: F-value	Girls: Han (n=160)	Girls: Pai-wan (n=290)	Girls: F-value
Waist/hip ratio	0.824 (0.004)	0.835 (0.003)	3.89*	0.781 (0.005)	0.799 (0.003)	8.72**
Waist/stature ratio	0.439 (0.005)	0.445 (0.004)	0.75	0.421 (0.004)	0.432 (0.003)	5.62*
Sitting height/stature ratio	0.520 (0.001)	0.521 (0.001)	0.29	0.520 (0.001)	0.525 (0.001)	11.28***
Stature/arm-span ratio	1.003 (0.002)	1.000 (0.002)	0.96	1.007 (0.002)	1.006 (0.001)	0.12
Biepicondylar of humerus/ bicondylar of femur ratio	0.662 (0.002)	0.655 (0.002)	7.35**	0.654 (0.003)	0.651 (0.002)	0.74
Biacromial/biiliac ratio	1.435 (0.008)	1.477 (0.006)	19.33***	1.427 (0.006)	1.452 (0.004)	10.79**

*p<0.05; **p<0.01; ***p<0.001

The sitting height/stature ratio represents the growth difference in the trunk or stature. This ratio comes to the highest point when the baby is born and then falls gradually until it reaches the lowest point in puberty[20,21]. That is, leg growth is more rapid than trunk growth in babies and children. This results in a gradual reduction in the sitting/stature ratio. Studies[11,22,23] indicate that the leg length growth spurt is earlier than that for the trunk. The sitting height/stature ratio in both genders is almost the same before ten years old. This ratio for girls is not higher than that for boys until they are ten or eleven years old or later[21]. Results from previous studies are similar to this study (Fig. 2). The sitting height/stature ratio of girls is higher than that of boys after they are eleven years old. This ratio for Pai-wan girls is higher than that for Han girls after controlling for age (Table 2). That is, for the same stature, the trunk of Pai-wan girls is relatively more slender than that of Han girls. These results are similar to those from other studies[24,25] that showed that the upper to lower segment ratio in Black school children was the smallest with a ratio from 0.85 to 0.95. This ratio for Chinese school children is the largest, from 1.1 to 1.2. When the leg lengths of the lower segment are the same, the upper segment and sitting height in Black school children are relatively shorter than White school children are longer and the Chinese school children are the longest[11].

In this study, the stature/arm span ratio of boys was from 0.99 to 1.02. The ratio for girls was between 0.99 to 1.03 (Fig. 2). The ratio for boys in Hong Kong from 2 to 16 years old is between 0.98 to 1.03 and that for girls is from 1.00 to 1.03[11]. The results from these two studies are quite similar. When the arm span is subtracted from the stature, the value for Hong Kong boys is from -0.1 to -0.8cm and the value for Hong Kong girls is from -0.1 to -0.4cm[11]. The arm span average subtracting the stature in Australian boys from 8 to 11.5 years old is 1.9cm and that for Australian girls is -0.4cm[26]. The average for Australian boys from 12 to 15 years old is 3.6cm and that for Australian girls is 0.6cm[26]. The difference between arm span and stature in adults is greater. The difference in Black females is 8.3cm and that for the White females is 3.3cm[27,28]. In this study, the average arm span subtracting stature is 0.06cm in boys and -0.69cm in girls. These results are similar to those from the Hong Kong study.

A skeletal growth study in Swiss children[22] showed that the timing of the growth spurt in the humerus is later, the duration is longer, and the intensity is stronger. The growth spurt in the legs is converse to that in the humerus. These growth differences would influence the biepicondylar breadth of humerus/bicondylar breadth of femur ratio of boys and girls at all ages. This study could not longitudinally trace the differences in the growth spurt of the skeleton. The biepicondylar breadth in the humerus/bicondylar femur ratio breath in boys in this study was higher than that in girls only at 12 years of age (Fig. 3). This Han boy ratio was significantly higher than that for Pai-wan boys after controlling for age (Table 2).

In the biacromial breadth of American boys[21] from 6 to 12 years old is somewhat broader than that for girls. The breadth of boys is significantly broader than that of girls from 12 years old to adulthood. The biiliac breadth of both genders in American children[21] is approximately equal from 6 to 10 years old. The breadth of boys from 10 to 15 years old is somewhat broader than that for girls. The breadth of boys and girls is similar after 15 years old. The biacromial breadth/biiliac breadth ratio of boys from 6 to 12 years old is somewhat higher than that of girls, and the breadth of boys is significantly higher than that of girls after 12 years old[21]. These differences involve the incoherence of timing, the duration and the intensity of the growth spurt in each part of the skeleton for both boys and girls[22]. They also influence the biacromial breadth/biiliac breadth ratio of both genders in children at all ages. This study shows only that the biacromial breadth/biiliac breadth ratio of boys at 7, 11, and 12 years of age is significantly higher than that of girls (Fig. 3). The biacromial breadth/biiliac breadth ratio of Pai-wan children is higher than that of Han children for boys and girls, respectively (Table 2).

The previous study shows the hereditary probabilities of stature, sitting height, knee height, arm span, chest circumference, and biiliac breadth are between 40% to 91%[29]. The hereditary probability of waist circumference is between 72% to 82% and that of the waist/hip circumference ratio is between 36% to 61%[30]. Nelson et al.[31] also confirmed that heredity plays an important role in the waist circumference and waist/hip circumference ratio. Analyses of covariance in this study shows that some of the body proportions in the same gender present racial differences (Table 2). In a word, the waist/hip circumference ratio, the waist circumference/stature ratio, the sitting height/stature ratio and the biacromial breadth/biiliac breadth ratio of Pai-wan girls are higher than those for Han girls. The biepicondylar breadth of the humerus/bicondylar breadth of the femur ratio for Han boys is higher than that for Pai-wan boys. The waist/hip circumference ratio and the biacromial breadth/biilac breadth ratio for Pai-wan boys are higher than those for Han boys. These results show that heredity may influence body proportions because of racial differences.

It is hoped that the current data on body proportions may serve as an essential reference for Taiwanese children and that these data may be helpful in recognizing conditions involving the physical growth of Han and aboriginal children. Further studies may develop a longitudinal comparison of body proportions between Han and other aboriginal children. These will provide a richer understanding of the body proportions among races.

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REFERENCES

1. Onat A, Sansoy V, Uysal O. Waist circumference and waist-to-hip ratio in Turkish adults: interrelation with other risk factors and association with cardiovascular disease. Int J Cardiol 1999;70:43-50.
2. Gillum RF. Distribution of waist-to-hip ratio, other indices of body fat distribution and obesity and associations with HDL cholesterol in children and young adults aged 4-19 years: the third national health and nutrition examination survey. Int J Obes Relat Metab Disord 1999;23:556-563.
3. Savva SC, Tornaritis M, Savva ME, Kourides Y, Panagi A, Silikiotou N, Georgiou C, Kafatos A. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int J Obes Relat Metab Disord 2000;24:1453-1458.
4. Lusky A, Lubin F, Barell V, Kaplan G, Layani V, Lev B, Wiener M. Body mass index in 17-year-old Israeli males of different ethnic backgrounds; national or ethnic-specific references? Int J Obes Relat Metab Disord 2000;24:88-92.
5. Patel S, Unwin N, Bhopal R, White M, Harland J, Ayis SA, Watson W, Alberti KG. A comparison of proxy measures of abdominal obesity in Chinese, European and South Asian adults. Diabet Med 1999;16:853-860.
6. Eveleth PB, Tanner JM. Worldwide variation in human growth. Cambridge: Cambridge University Press, 1976.
7. Malina RM. Biological substrata. In: Comparative studies of blacks and whites in the United States. Miller KS, Dreger RM, eds. New York: Seminar Press, 1973: 53-123.
8. Tanner JM, Hayashi T, Preece MA, Cameron N. Increase in length of leg relative to trunk in Japanese children and adults from 1957 to 1977: comparison with British and with Japanese-Americans. Ann Hum Biol 1982;9:411-423.
9. Hou I, Hu SW. The body measurement of Atayal in Gaogan region of Taiwan. J Formos Med Assoc 1953; 52:519-530. (in Chinese)
10. Chen GB. The study of physical development of Lanyu aboriginal. J Formos Med Assoc 1948;47:40-41. (in Chinese)
11. Cheng JC, Leung SS, Lau J. Anthropometric measurements and body proportions among Chinese children. Clin Orthop Relat Res 1996;323:22-30.
12. Cheng JC, Leung SS, Chiu BS, Tse PW, Lee CW, Chan AK, Xia G, Leung AK, Xu YY. Can we predict body height from segmental bone length measurements? A study of 3,647 children. J Pediatr Orthop 1998;18:387-393.
13. Gasser T, Sheehy A, Molinari L, Largo RH. Sex dimorphism in growth. Ann Hum Biol 2000;27:187-197.
14. Carter JEL. The Heath-Carter somatotype method. San Diego, CA: San Diego State University Syllabus Service, 1980.
15. Lohman TG, Roche AF, Martorell R. Anthropometric standardization reference manual. Champaign, IL: Human Kinetics Books, 1988.
16. Moreno LA, Fleta J, Mur L. Waist circumference values in Spanish children-gender related differences. Eur J Clin Nutr 1999;53:429-433.
17. Chu NF, Rimm EB, Wang DJ, Liou HS, Shieh SM. Relationship between anthropometric variables and lipid levels among school children: the Taipei children heart study. Int J Obes Relat Metab Disord 1998; 22:66-72.
18. Lurbe E, Alvarez V, Liao Y, Tacons J, Cooper R, Cremades B, Torro I. The impact of obesity and body fat distribution on ambulatory blood pressure in children and adolescents. Am J Hypertens 1998;11:418-424.
19. Asayma K, Hayashi K, Hayashibe H, Uchida N, Nakane T, Kodera K, Nakazawa S. Relationships between an index of body fat distribution (based on waist and hip circumferences) and stature, and biochemical complications in obese children. Int J Obes Relat Metab Disord 1998;22:1209-1216.
20. McCammon RB. Human growth and development. Springfield, IL: Charles C Thomas, 1970.
21. Roche AF, Malina RM. Manual of physical status and performance in childhood: Vol. 1. Physical status. New

York: Plenum, 1983.
22. Sheehy A, Gasser T, Molinari L, Largo RH. An analysis of variance of the pubertal and midgrowth spurts for length and width. Ann Hum Biol 1999;26:309-331.
23. Sheehy A, Gasser T, Molinari L, Largo RH. Contribution of growth phases to adult size. Ann Hum Biol 2000;27:281-298.
24. Gerver WJM, Drayer NM, Schaafsma W. Reference values of anthropometric measurements in Dutch children. Acta Paediatr Scand 1989;78:307-313.
25. Jacobs M, Joubert G, Hoffman M. Anthropometric assessment of children in Mamre. S Afr Med J 1988;74: 341-343.
26. Engstrom FM, Roche AF, Mukherjee D. Differences between arm span and stature in white children. J Adolesc Health Care 1981;2:19-22.
27. Steele MF, Chenier TC. Arm-span, height, and age in black and white women. Ann Hum Biol 1990;17:533-541.
28. Steele MF, Mattox JW. Correlation of arm-span and height in young women of two races. Ann Hum Biol 1987;14:445-447.
29. Chatterjee S, Das N, Chatterjee P. The estimation of the heritability of anthropometric measurements. Appl Human Sci 1999;18:1-7.
30. Rose KM, Newman B, Mayer Davis EJ, Selby JV. Genetic and behavioral determinants of waist-hip ratio and waist circumference in women twins. Obes Res 1998;6:383-392.
31. Nelson TL, Vogler GP, Pededsen NL, Miles TP. Genetic and environmental influences on waist-to-hip ratio and waist circumference in an older Swedish twin population. Int J Obes Relat Metab Disord 1999;23: 449-455.