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Chronological Changes in Genetic Variance and Heritability of Anthropometric Characteristics Among Chinese Twin Infants

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Abstract. In order to examine the chronologic changes in genetic variance and heritability of anthropometric characteristics of Chinese infants in Taiwan, a total of 521 pairs of same-sexed twin neonates given birth in four major general teaching hospitals in Taipei City were studied. Based on the placental pattern and 12 red blood cell antigens, 428 MZ and 93 DZ twin pairs were identified and followed up to the age of one year. There was no significant genetic variance for all anthropometric characteristics adjusted for sex and gestational week before the age of six months. After adjusting for sex and gestational week, a significant genetic variance was observed at the age of six months, with heritability values of 0.51 (weight), 0.63 (head circumference), 0.77 (chest circumference), and 0.53 (arm circumference), as well as at one year, although with considerably lower heritability values. This implies that growth is dynamically determined by both genetic and environmental factors during infancy.

Key words: Heritability, Anthropometry, Infants, Twins

Infancy is a period of rapid growth and development, both physically and mentally. Twins are usually born premature with a low birth weight due to intrauterine competition, but then grow and catch up with singletons in the first year of life. Growth in this period is attributable to both environmental and genetic factors. However, the relative importance of these two components remains to be elucidated. The specific aim of this study is to assess chronologic changes in genetic variance and heritability of anthropometric characteristics during infancy among Chinese twin neonates.

MATERIALS AND METHODS

Twin neonates delivered in four general teaching hospitals in Taipei during the period, 1 October 1985 to 31 December 1988, were serially recruited as the study population. Among a total of 844 twin pairs delivered, there were 63 pairs with one or both cotwins stillborn and/or affected by congenital malformations. In the remaining 781 twin pairs with both cotwins alive, there were 643 same-sexed (318 male and 325 female) and 138 different-sexed pairs.

Zygosity was determined by the placental pattern and 12 red blood cell antigen markers (A, B, C, D, E, c, e, M, N, Le^a, Le^b and P_1). Twin pairs who were monochorionic or concordant in all genetic markers were classified as MZ, while dichorionic pairs, or pairs with no information on placental pattern, were classified as DZ if they had one or more genetic markers discordant. Totally, there were 521 same-sexed pairs with available data on both anthropometric characteristics and zygosity. Among them, 428 pairs were MZ (199 male and 229 female) and 93 pairs were DZ (51 male and 42 female). The MZ:DZ ratio was consistent to what we reported previously [1].

Anthropometric characteristics, including body weight, body height, head circumference, chest circumference, and arm curcumference, were measured at birth and at ages one month, two months, four months, six months, nine months, and twelve months. All measurementes were carried out by a public health nurse according to a standard protocol, without knowing the zygosity of the study subjects. While anthropometric measurements at birth were made at study hospitals, later ones were made through home visits. By 31 December 1988, anthropometric data were available for the following numbers of pairs followed up at the different ages: 93 pairs (one month), 93 (two months), 107 (four months), 152 (six months), 74 (nine months), and 121 (twelve months).

In order to adjust for possible effects of sex and gestational week on the anthropometric measurements, multiple regression analyses were used to derive predicted values of anthropometric characteristics for each twin individual. Data of one cotwin randomly selected from each pair were used to estimate regression coefficients in the regression equations. The residual values computed by subtracting predicted values from observed values were used as the adjusted data for further analysis.

Mean values of adjusted anthropometric measurements in MZ and DZ twins were first compared and tested by t' test [2]. If there was no significant difference between MZ and DZ twins, then the differences in total variance of adjusted anthropometric characteristics were tested by F' test [4]. In case of no difference, within-pair genetic variance [5] and Falconer's heritability index [3] were estimated.

RESULTS

The mean values of anthropometric characteristics are shown in Table 1. It can be noted that all characteristics obviously increased considerably over the first year of age in all twins, but with no significant differences in mean values between MZ and DZ pairs.

The results of the genetic analysis are summarized in Tables 2-6, showing within-pair and among-pair mean squares, intrapair correlations, and heritability values (Falconer's index) for body weight (Table 2), body height (Table 3), head circumference (Table 4), chest circumference (Table 5), and arm circumference (Table 6). It can be noted that for all of the traits examined, considerable differences are found at the various ages considered, from birth to one year, with special respect to heritability estimates.

Table 1 - Chronological changes of anthropometric characteristics in MZ and DZ twin pairs

Anthropometric characteristic	Zygosity	Age (months)						
		Birth	1	2	4	6	9	12
Weight (kg)	MZ	2.4	3.6	5.0	6.5	7.5	8.6	9.4
	DZ	2.6	4.3	5.1	6.6	7.4	8.4	9.1
Height (cm)	MZ	45.7	52.3	56.5	62.5	66.9	72.2	75.6
	DZ	46.4	53.8	56.5	61.6	67.0	71.6	75.2
Head circumference (cm)	MZ	32.2	36.0	38.0	40.7	42.7	44.7	45.8
	DZ	32.6	36.7	37.7	40.9	42.5	44.7	45.8
Chest circumference (cm)	MZ	30.0	35.3	38.5	41.6	43.9	45.2	46.6
	DZ	30.4	35.7	38.4	41.8	43.5	45.0	45.9
Arm circumference (cm)	MZ	–	11.0	12.6	13.8	14.2	14.4	14.6
	DZ	–	11.4	12.5	13.8	13.8	14.1	13.5

Table 2 - Within-pair mean square (MSW), among-pair mean square (MSA), intrapair correlation (r) and heritability of body weight adjusted for sex and gestational week by age

Age (months)	MZ				DZ				Heritability
	N	MSW	MSA	r	N	MSW	MSA	r	
Birth	415	0.06	0.20	0.52	84	0.06	0.26	0.62	–
1	63	0.11	0.66	0.72	18	0.10	0.62	0.71	0.02
2	63	0.11	0.83	0.77	18	0.10	0.71	0.75	0.05
4	66	0.16	1.58	0.82	24	0.21	0.88	0.62	0.41
6	90	0.19	1.60	0.79	30	0.45	1.46	0.53	0.51**
9	42	0.21	2.39	0.84	22	0.52	1.10	0.36	0.96**
12	66	0.24	2.08	0.79	30	0.42	2.07	0.67	0.25*

* $p<0.05$; ** $p<0.01$ for the F test of the statistical significance of genetic variance.

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Table 3 - Within-pair mean square (MSW), among-pair mean square (MSA), intrapair correlation (r) and heritability of body height adjusted for sex and gestational week by age

Age (months)	MZ				DZ				Heritability
	N	MSW	MSA	r	N	MSW	MSA	r	
Birth	413	2.46	8.80	0.57	84	2.86	7.76	0.47	0.19
1	66	1.86	19.43	0.83	19	1.89	10.91	0.71	0.24
2	66	1.86	19.43	0.83	19	1.89	9.45	0.67	0.32
4	74	2.11	14.28	0.74	24	2.04	15.45	0.77	–
6	107	2.60	10.49	0.60	31	4.56	18.82	0.61	–
9	46	2.43	15.68	0.73	24	2.30	12.12	0.68	0.10
12	83	1.63	16.45	0.82	33	2.65	13.49	0.67	0.30*

* $p<0.05$ for the F test of the statistical significance of genetic variance.

Table 4 - Within-pair mean square (MSW), among-pair mean square (MSA), intrapair correlation (r) and heritability of head circumference adjusted for sex and gestational week by age

Age (months)	MZ				DZ				Heritability
	N	MSW	MSA	r	N	MSW	MSA	r	
Birth	403	1.06	3.40	0.54	84	1.06	3.96	0.60	–
1	72	0.44	2.80	0.73	21	0.59	2.05	0.56	0.34
2	72	0.44	2.91	0.74	21	0.59	2.03	0.55	0.37
4	81	0.51	2.82	0.70	26	0.82	2.34	0.48	0.43
6	119	0.42	3.10	0.76	33	1.42	3.71	0.44	0.63**
9	48	0.48	3.92	0.78	26	1.40	3.39	0.42	0.73**
12	87	0.44	3.39	0.77	35	1.07	4.03	0.58	0.38**

** $p<0.01$ for the F test of the statistical significance of genetic variance.

DISCUSSION

The heritability and genetic variance of anthropometric characteristics among Chinese twin infants have never been examined. We observed a significant genetic variance for body weight, head circumference, chest circumference and arm circumference at ages of six months and older, and a significant genetic variance for body height at the age of

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Table 5 - Within-pair mean square (MSW), among-pair mean square (MSA), intrapair correlation (r) and heritability of chest circumference adjusted for sex and gestational week by age

Age (months)	MZ				DZ				Heritability
	N	MSW	MSA	r	N	MSW	MSA	r	
Birth	1	400 –	1.76	5.20	0.51	83	2.06	7.26	0.56
1	71	1.71	5.81	0.55	21	1.05	4.57	0.63	–
2	71	1.71	6.62	0.59	21	1.05	4.53	0.62	–
4	76	1.32	8.72	0.74	24	1.19	4.85	0.61	0.26
6	110	1.55	7.78	0.67	30	3.18	5.69	0.28	0.77**
9	45	1.66	10.58	0.73	25	2.58	5.70	0.38	0.70*
12	79	1.05	7.06	0.74	29	1.41	5.74	0.61	0.27*

* $p<0.05$, ** <0.01 for the F test of the statistical significance of genetic variance.

Table 6 - Within-pair mean square (MSW), among-pair mean square (MSA), intrapair correlation (r) and heritability of arm circumference adjusted for sex and gestational week by age

Age (months)	MZ				DZ				Heritability
	N	MSW	MSA	r	N	MSW	MSA	r	
1	71	0.47	1.79	0.58	20	0.31	2.48	0.78	–
2	71	0.47	1.80	0.58	20	0.31	2.57	0.79	–
4	68	0.33	3.56	0.77	22	0.44	2.27	0.68	0.19
6	113	0.46	2.57	0.69	31	0.89	2.23	0.43	0.53**
9	48	0.42	1.99	0.65	26	0.45	1.47	0.53	*.25
12	85	0.27	2.31	0.79	34	0.46	1.87	0.61	0.37*

* $p<0.05$, $p<0.01$ for the F test of the statistical significance of genetic variance.

one year. It is interesting to find an increase in heritability from birth up to the age of nine months for body weight, head circumference, chest circumference, and arm circumference. This may result from an increased relative importance of genetic factors in the determination of these traits over the first year of age. The higher intrauterine competition of monochorionic twins may be responsible for larger differences in anthropometric characteristics in MZ than DZ cotwins, and perhaps for some residual influence on early development.

The within-pair mean squares were found to be significantly smaller than among-pair mean squares for all traits. The high similarity in anthropometric characteristics may result from either common environment or common genes shared by cotwins. Since heritability for these characteristics was low before the age of six months, common environment must make a major contribution to the similarity between cotwins, either MZ or DZ, during this period of time. Heritability was higher, however, at the age of one year, implying that both genetic and environmental factors are important at this stage in the determination of anthropometric characteristics.

It seems reasonable to imply that the anthropometric growth and development is multifactorially and dynamically determined by both genetic and environmental factors. In the first six months of life, anthropometric characteristics are basically influenced by intrauterine and postnatal environment. As intrauterine effects, such as gestational age and placentation, gradually decrease, and the postnatal environment remains similar between cotwins, the relative importance of genetic factors increases. However, during the same period of time cotwin-shared postnatal environment also becomes more and more important. This stresses similarity in both MZ and DZ cotwins and reduces the heritability of anthropometric characteristics. Moreover, although twins are born under a disadvantageous condition, better postnatal care may improve their growth to catch up with that of singletons.

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