Acta Genet Med Gemellol 33:509-514 (1984)

TWIN RESEARCH 4 - Part C: Clinical Studies
Proceedings of the Fourth International Congress on Twin Studies (London 1983)

Estimates of Genetic Variance for Some Selected Morphometric Characters: A Twin Study

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Abstract. Results on genetic variability in some of the morphometric characters on head and face, body girths and skin folds, based on 45 MZ and 67 like-sex DZ twin pairs, are presented. The data were subjected to a method which eliminated possible biases in the estimated genetic variances that could result from heterogeneity of total variances between zygosities of the 17 head and face measurements, heterogeneity was observed for only bizygomatic diameter. Head breadth means differed between MZ and DZ twins, indicating bias in the trait's genetic variance analysis. The results indicated a significant genetic component in these morphometric traits. For 11 girth and skinfold measurements, the t'-test based on hierarchical structure of twin data, also failed to reveal any appreciable difference between the mean values of MZ and DZ twins. Heterogeneity of total variance between zygosities was observed for three skinfold measurements, ie, biceps, triceps and suprailiac. The girth measurements, however, did not reveal any heterogeneity of total variances between the zygosities. The estimates of genetic variance revealed stronger genetic component for the girths than for the skinfolds.

Key words: Genetic variance, Morphometric characters, Twins

INTRODUCTION

Twins have been used by many investigators [6,8,10-13,16,18,19], in the genetic analysis of body morphology usually based on the ratio of MZ vs DZ intrapair variances – a procedure assuming equal environmental variances in the two types of twins. However, environmental effects include all nongenetic effects like cytoplasmic inheritance, maternal genotype, pre- and postnatal factors, maternal and developmental factors, some of which are unique to the twinning process itself and may well constitute further source of variance in twin data [7,14]. Christian et al [2] have proposed a test for homogeneity of total variances, noting that MZ and DZ pairs cannot be compared if there is evidence that their total variances differ. The inequality of variances between zygosities has already been shown for a number of dental [5] and dermatoglyphic variables [15].

Christian and Norton [3] also stress that the past twin studies usually failed to report whether the means of the two zygosity groups were compared statistically. If ever the means were compared, the usual practice was to consider the members of MZ and DZ pairs as samples of independent individuals. This assumption has been challenged by Christian and his colleagues [1,4] who have proposed a t'-test to compare the means between MZ and DZ pairs. The test is based upon the nested structure of the twin data.

In the present paper we have incorporated most of these methodological refinements in a twin data analysis of some anthropometric traits – stable measures such as head and face measurements, and labile ones such as skinfolds and body girth measurements.

MATERIALS AND METHODS

Seventeen measurements on head and face, five skinfold and six girth measurements were taken on a sample of 45 MZ and 67 DZ like-sexed twin pairs drawn from an urban Punjabi population of Chandigarh. The subjects belonged to upper and middle socioeconomic group of the North Indian society and enjoyed a good nutritional status. Their age varied between 14 and 18 years. Measurements on head and face were taken after Martin and Saller [9], and those of skinfolds and girths according to Weiner and Lourie [20]. Abdomen girth, however, was taken at the level of umbilicus. All paired measurements were taken on the left side of the body. Zygosity was determined on the basis of blood groups (A_1A_2BO, MN, CcDE, Kell and Duffy), ABH secretor factor, and PTC tasting ability.

To test the equality of means between MZ and DZ twins for each of the 28 variables studied, the t' test based on the nested or hierarchical structure of twin data [3] was used. In this mixed model, the analysis of variance involved zygosities (fixed effect), twin pairs within zygosities (random effect), and two members within twin pairs (random effect), in that order. The statistical test comparing between zygosities, therefore, used only the among-pair mean squares of MZ and DZ twins as the error term, because the two members of a twin pair could not be considered independent of each other [3]. The further statistical treatment of the data was based on a comparatively new method of estimating genetic variance [1,2]. The main advantage of this method is that it does not require the total MZ and DZ mean squares to be equal; the method makes allowance for these variances if they do differ. But like other studies, the assumption that the environmental covariances between MZ and DZ twins are the same remains valid.

RESULTS AND DISCUSSION

The comparison of means for head and face measurements between MZ and DZ twins (Table 1a) showed significant association of twinning type with mean head breadth ($P < 0.01$) only. Head circumference, head length and head height also showed greater differences between the means of MZ and DZ twins, though not reaching statistical significance. These differences might only be due to chance, but there is reason to suspect that for head variables, especially head breadth, there might be different biological determinants in MZ and DZ twins. Christian et al [4] note that if the means differ between zygosities, further statistical analysis of twin data is unwarranted and generalization to singleton population is hazardous, one reason being that genetic variances may not be equal between twin types [14]. However, we have included the head breadth variable in the final genetic analysis for the sake of completion. Comparison of means for skinfold and girth measurements (Table 1b) also showed no association between mean values and twinning type.

Table 1 - Significance of Differences Between MZ and DZ Means

Measurements	t'	P	df
a) Head and Face Measurements			
Head circumference	−1.547	0.125	89.28
Head length	−1.267	0.208	89.83
Head breadth	−2.849	0.005*	86.65
Head height	−1.378	0.171	90.48
Minimum frontal diameter	−0.831	0.408	75.61
Bizygomatic diameter	−0.874	0.384	75.29
Bigonial diameter	−0.520	0.604	76.67
Nasal height	0.459	0.647	76.81
Nasal breadth	−0.651	0.516	82.77
Nasal depth	0.868	0.387	85.52
Mouth breadht	−0.816	0.416	84.81
Ear length	−0.492	0.624	79.52
Ear breadth	−1.309	0.194	77.12
Physiog. facial length	−0.068	0.945	77.21
Morph. facial length	−0.028	0.977	83.53
Physiog. sup. facial length	−0.025	0.979	84.10
Lower jaw height	0.054	0.956	85.07
b) Girth and Skinfold Measurements			
Chest girth	−0.179	0.857	89.73
Abdomen girth	−0.806	0.421	91.62
Upper arm girth	0.157	0.875	92.68
Fore arm girth	−0.213	0.831	90.82
Thigh girth	−0.124	0.901	89.33
Calf girth	−0.695	0.488	93.42
Biceps skinfold	0.186	0.852	72.37
Triceps skinfold	−0.193	0.847	73.98
Subscapular skinfold	0.144	0.885	87.79
Suprailiac skinfold	−0.853	0.395	105.66
Calf skinfold	−0.419	0.676	87.53

Table 2 presents the results of the analysis of variance. The left half of the table presents the among pairs (AMS) and within-pairs (WMS) mean squares for MZ and DZ twins. The right half of the table displays the probability that the total variances of the MZ and DZ twins are equal, followed by within-pair (G_{WT}) and among-component (G_{CT}) estimates of genetic variance and their level of significance. According to Christian et al [2] G_{WT} can be used when the probability of equal variances is greater than 0.20 and in all other cases the more conservative estimate, G_{CT}, should be used.

By employing Christian's criterion, all the 17 variables on head and face were found to have significant genetic component. The heterogeneity of total variances between MZ and DZ twins was observed only for bizygomatic diameter. The estimates of genetic variance for head height and bizygomatic diameter are significant at the 5% level only, while for all other variables, these estimates are highly significant ($P < 0.001$), thus showing that the head and facial morphology has a strong genetic basis. Of the five

Table 2 - Analysis of Variance and Estimates of Genetic Variance

Variable	MZ twins			DZ twins			Probability for F' test on total variance	Estimates of genetic variance	
	No.	AMS	WMS	No.	AMS	WMS		G_{WT}	G_{CT}
a) Head and Face Measurements									
Head circumference	45	17.379	0.131	67	14.813	0.878	0.666	0.747***	1.656
Head length	45	2.447	0.059	67	2.121	0.158	0.702	0.098***	0.212
Head breadth	45	1.016	0.044	67	0.799	0.130	0.588	0.086***	0.151
Head height	42	0.742	0.107	64	0.808	0.187	0.536	0.079*	0.006
Minimum frontal diameter	42	0.709	0.011	64	0.477	0.089	0.344	0.077***	0.154*
Bizygomatic diameter	42	2.324	0.011	64	1.547	0.100	0.194†	0.088***	0.432*
Bigonial diameter	42	1.880	0.021	64	1.312	0.100	0.263	0.078***	0.323
Nasal height	42	1.051	0.007	64	0.736	0.059	0.284	0.051***	0.183
Nasal breadth	42	0.269	0.002	64	0.229	0.025	0.790	0.023***	0.031
Nasal depth	42	0.139	0.003	64	0.129	0.013	1.000	0.010***	0.010
Mouth breadth	42	0.507	0.008	64	0.460	0.059	0.993	0.051***	0.049
Ear length	42	0.520	0.007	64	0.399	0.055	0.552	0.047***	0.084
Ear breadth	42	0.125	0.005	64	0.088	0.025	0.572	0.019***	0.028*
Physiog. facial length	42	4.250	0.037	64	3.023	0.353	0.361	0.316***	0.772
Morph. facial length	42	2.761	0.022	64	2.407	0.141	0.732	0.119***	0.236
Physiog. sup. facial length	42	1.279	0.014	64	1.135	0.088	0.820	0.073***	0.108
Lower jaw height	42	0.378	0.010	64	0.346	0.074	0.790	0.063***	0.047

Table 2 - *Contd*

Variable	MZ twins			DZ twins			Probability for F' test on total variance	Estimates of genetic variance	
	No.	AMS	WMS	No.	AMS	WMS		G_{WT}	G_{CT}
b) Girth and Skinfold Measurements									
Chest girth	45	262.510	0.982	67	266.822	7.221	0.647	6.238***	20.963
Abdomen girth	45	173.541	2.734	67	158.771	14.186	0.924	11.452***	13.110
Upper arm girth	45	24.788	0.135	67	23.421	1.812	0.981	1.676***	1.521
Fore arm girth	45	22.742	0.096	67	20.310	0.549	0.723	0.452***	1.442
Thigh girth	45	148.424	1.140	67	126.687	4.603	0.615	3.463***	12.600
Calf girth	45	47.850	0.395	67	46.253	3.545	0.924	3.150***	2.374
Biceps skinfold	45	6.026	0.313	67	2.939	0.641	0.018†	0.327**	1.707***
Triceps skinfold	45	28.524	0.699	67	14.783	4.388	0.080†	3.689***	8.715***
Subscapular skinfold	45	26.428	0.475	67	21.530	5.912	0.962	5.437***	5.167*
Suprailiac skinfold	45	29.398	2.100	67	43.908	7.753	0.057†	5.653***	−4.428
Calf skinfold	45	28.597	1.160	67	23.122	4.207	0.717	3.046***	4.260

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

† Among component (G_{CT}) estimate must be used if the probability of equal total variance is less than 0.20.

skinfold measurements considered in the present study, biceps, triceps and suprailiac skinfolds had probabilities less than the chosen alpha level of 0.20, which led us to reject the G_{WT} as an unbiased estimation of genetic variance. For the various girth measurements, however, the level of probabilities was much higher than 0.20. It is interesting to note that all the skinfold means indicated total variance heterogeneity between zygosities, while none of the six girth measures revealed any such heterogeneity, indicating a higher environmental component for skinfold measures than for the girth measurements. However, by employing Christian's criterion, the skinfold measures as well as the girth measurements were found to have a significant genetic component.

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