The Influence of Genetic and Environmental Factors in Estimations of Current Body Size, Desired Body Size, and Body Dissatisfaction

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The objective was to investigate the genetic epidemiology of figural stimuli. Standard figural stimuli were available from 5,325 complete twin pairs: 1,751 (32.9%) were monozygotic females, 1,068 (20.1%) were dizygotic females, 752 (14.1%) were monozygotic males, 495 (9.3%) were dizygotic males, and 1,259 (23.6%) were dizygotic male-female pairs. Univariate twin analyses were used to examine the influences on the individual variation in current body size and ideal body size. These data were analysed separately for men and women in each of five age groups. A factorial analysis of variance, with polychoric correlations between twin pairs as the dependent variable, and age, sex, zygosity, and the three interaction terms (age x sex, age x zygosity, sex x zygosity) as independent variables, was used to examine trends across the whole data set. Results showed genetic influences had the largest impact on the individual variation in current body size measures, whereas non-shared environmental influences were associated with the majority of individual variation in ideal body size. There was a significant main effect of zygosity (heritability) in predicting polychoric correlations for current body size and body dissatisfaction. There was a significant main effect of gender and zygosity in predicting ideal body size, with a gender x zygosity interaction. In common with BMI, heritability is important in influencing the estimation of current body size. Selection of desired body size for both men and women is more strongly influenced by environmental factors.

Figural stimuli (Stunkard et al., 1983) are a widely utilised measure of body image (Thompson, 1995), yielding three measures: current body size, desired body size, and discrepancy scores between these two measures. Given the high correlation between the current body size estimations and weight and its robustness for classifying individuals as obese or lean (Bulik et al., in press), one could predict that the genetic epidemiology of this measure would be similar to that of body mass index (BMI), with sizeable influence of genetic factors. However, self-reported likeness to body silhouettes may be expected to differ somewhat from self-reported BMI, in that the stability of body image can be affected by a range of variables, including eating disorder status, and mood and food cues (Carter et al., 1996).

In contrast, desired body size is thought to be largely a sociocultural construct (Stice, 1994), reflecting current cultural norms. For example, over the last 40 years there has been a significant increase in the number of women's magazine articles and advertisements on weight loss and dieting (Wiseman et al., 1992), a significant decrease in the average BMI of centrefolds and beauty contestants (Garner et al., 1980), and an increased prevalence of bulimia nervosa (Kendler et al., 1991). The purpose of the current report is to investigate the genetic epidemiology of figural stimuli, and in particular to compare the differences in genetic epidemiology between the estimated current body size and the desired body size.

Method

Participants

The participants were twins from the Virginia 30,000 data set that includes 14,763 twin individuals (and 13,331 of their relatives). The twin sample was ascertained from two sources (Truett et al., 1994). Public birth records in the Commonwealth of Virginia were matched with other public records to obtain current addresses for Caucasian twins born in Virginia between 1915 and 1971 (*N* = 11,416 individuals, 77%), known as the Virginia Twin Registry (VTR). The remainder of the sample (*N* = 3,347 individuals, 23%) responded to a letter published in the newsletter of the American Association of Retired Persons (AARP). In 1985–1987, after a pilot mailing of the questionnaire, all adult twins (aged 18 and over) were mailed a 16-page "Health and Lifestyle" questionnaire which, in addition to demographic information, contained questions about health, weight, consumption of alcohol and tobacco, passive smoking, life-events, personality, social support, social attitudes, psychiatric symptoms, disease history and

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family history. The questionnaire also contained questions for accurate determination of zygosity. Written informed consent was obtained as part of this process. The average age of the twin sample at the time of completing the questionnaire was 50.6 years (*SD* = 18.4).

Measures

Zygosity. Zygosity was determined on the basis of two standard questions that have > 95% accuracy (Eaves et al., 1989). Further, for those twin pairs from the VTR, zygosity was determined blindly by both standard questions and photographs, and 119 pairs of uncertain zygosity were analyzed using 8 RFLP markers (Spence, 1988). Zygosity assignment was recently revalidated with highly polymorphic PCR. Both the revalidated zygosity assignment and the zygosity assignment based on questions alone were available for 2,739 twins. Comparison of the two zygosity assignments showed that these were the same for 2,640 twins and differed for 99 twins, representing a 3.75% misclassification rate. The revalidated zygosity assignment was used preferentially where available.

Of the 5,325 complete pairs where data on global body image were available for this study, 1,751 (32.9%) were monozygotic females (MZF), 1,068 (20.1%) were dizygotic females (DZF), 752 (14.1%) were monozygotic males (MZM), 495 (9.3%) were dizygotic males (DZM), and 1,259 (23.6%) were dizygotic male-female pairs (DZMF).

Global body image. The self-report "Health and Lifestyle" questionnaire contained a commonly utilized measure of global body image, the figural stimuli developed by Stunkard, Sorenson and Schlusinger in 1983. These stimuli contain nine male and nine female schematic figures that range from underweight to overweight. Subjects are asked to rate the figures based on their (i) current size ("which silhouette is closest to your usual appearance?"), and (ii) ideal size ("which of these figures would you like to look like?"). The difference between the ratings is a discrepancy index and is considered to represent the individual's level of dissatisfaction with their current size. In the current study, body dissatisfaction was calculated by subtracting the ideal size from the current body size. Studies indicate that the current and ideal size ratings meet acceptable standards of reliability (Thompson, 1995).

In order to determine the representativeness of the sample with respect to body size, we examined both the age and current body mass index (BMI) of concordant-respondent pairs and discordant-respondent pairs. If there is a bias in the sample, there will be a difference between these two variables for those twins whose cotwins did not participate in the questionnaire compared with those twins whose cotwins did participate. A comparison of women (MZF and DZF) indicated that concordant-respondent pairs were significantly older ($F = 71.37$, $p = 0.0001$) and therefore significantly heavier ($F = 5.14$, $p = 0.02$) than discordant-respondent pairs. The mean age of the concordant-respondent pairs and the discordant-respondent pairs were 53.03 years and 33.54 years respectively. The mean BMI of the concordant-respondent pairs and the discordant-respondent pairs were both in the normal range, at 23.89 and 22.57 respectively. While the concordant-respondent males were significantly older than discordant-respondent males ($F = 89.26$, $p = 0.0001$), with a mean age of 48.06 and 33.44 years respectively, there were no significant differences in BMI ($F = 0.66$, $p = 0.42$). Likewise, the concordant-respondent DZMF twins were significantly older than the discordant-respondent DZMF twins ($F = 151.65$, $p = 0.0001$), with mean respective ages of 48.49 and 31.42 years, but no significant differences in BMI ($F = 1.13$, $p = 0.29$). This indicates that older people were more likely to answer the questionnaire than younger people were (reflecting the use of a retired person's sample). This age differential most pronounced for women as older age in women (up to 70 years) was associated with a significantly higher weight.

Statistical Analysis. Polychoric correlations and the associated asymptotic standard errors between twin 1 and twin 2 were calculated for each of the three measures — current body size, ideal body size, and the discrepancy score (which has been interpreted to be a measure of dissatisfaction with current body size). This resulted in 25 polychoric correlations for each dimension, one for each of five age groups (18–30, 30–40, 40–50, 50–60, > 60 years), within the five zygosity groups.

The traditional twin modelling approach (Kendler, 1993) was utilised to examine the sources of individual difference of the current body size and ideal body size measures separately for men and women in each of the five age groups for MZ and DZ same-sex twins only. Raw ordinal data were used in a univariate model-fitting script using Mx (Neale, 1997), utilising maximum likelihood analysis. The population variance of a measure can be due to four different influences: additive genes (A), dominant genetic action (D), common or shared environment (C), and non-shared or unique environment (E). Initially, a full model (ADE) was fitted to the data, followed by an ACE model, an AE model, a CE model, and a model containing only non-shared environment. Models are compared by subtracting the fit function (–2 * Log-likelihood of raw data) and the degrees of freedom (df) of the full model from the fit function and df of each sub-model, yielding a chi-square value and an associated df. The goal of model fitting is to explain the observed data as an optimal combination of goodness-of-fit and parsimony. As the final part of this procedure, the proportion of variance contributed by genes (a^2 or d^2), shared environment (c^2), and non-shared environment (e^2) to estimated and ideal body size was estimated, along with 95% confidence intervals.

In order to summarise findings for the complete data set, a regression model was utilised. A summary data set was created, specifying the gender, zygosity (MZ or DZ), age group, and polychoric correlation for each of the 25 groups within each dimension. In addition, a weighting variable was created for each group, the inverse of the square of the asymptotic error, equivalent to the inverse of the variance of the polychoric correlation. The weight statement has no effect on the degrees of freedom or the number of observations, but is used when calculating the means and performing multiple comparison tests. These data were analyzed using PROC GLM, a procedure that uses the method of least squares to fit general linear models. For the current analyses, the specific model utilised was

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a factorial analysis of variance, with the polychoric correlation as the dependent variable. The independent variables included age, sex, zygosity, and the three possible interactions: sex x zygosity, sex x age group, and zygosity x age group. Type III sums of squares (SS) was specified, giving the unique SS for each hypothesis tested within the model. These analyses were carried out using SAS version 6.12 (SAS Institute Inc., 1996).

Results

The 25 polychoric correlations, and associated standard errors, for the five age x zygosity groups, are summarised in Table 1. The polychoric correlation for the current body size is consistently higher for MZF than DZF for all age groups. The MZ:DZ correlation ratio ranges from 1.6 for women aged 60 years or over, to 3.1 for women between the ages of 18 and 30. Similarly, the polychoric correlations for MZM are always higher than DZM, with the correlation ratio ranging from 1.5 for men aged 50–60 years, to 12.8 for men aged between 30 and 40. Across most age groups, female twins choose more similar body sizes than male twin pairs. The polychoric correlations for DZMF tend to decrease with age, indicating that brothers become less like their sisters with respect to current body size.

With respect to desired body size, the polychoric correlations for MZF are consistently higher than for DZF. The MZ:DZ correlation ratio ranges from 1.7 for women over 60 years of age to 8.4 for women aged between 40 and 50 years. For the male twin pairs, there is one occasion where the DZ correlation is higher than the MZ correlation — males aged between 50 and 60 years. The remaining MZ:DZ correlation ratios range from 1.6 for men over 60 years to 5.8 for men aged 40 to 50. For both MZ and DZ twins the correlations for desired body size

Table 1

Twin Correlations and Summary Statistics — Current Body Size, Desired Body Size, and Body Size Dissatisfaction.

	Current Body Size			Desired Body Size			Body Size Dissatisfaction		
Group	*N* pairs	*r*[a]	ASE[b]	*N* pairs	*r*[a]	ASE[b]	*N* pairs	*r*[a]	ASE[b]
MZF									
18–30	302	0.671	.038	293	0.583	.054	292	0.528	.051
30–40	197	0.600	.051	196	0.451	.073	196	0.530	.060
40–50	94	0.719	.056	93	0.660	.080	93	0.570	.081
50–60	396	0.672	.030	387	0.496	.048	387	0.558	.041
> 60	765	0.588	.026	734	0.446	.036	731	0.504	.032
DZF									
18–30	178	o.215	.078	170	0.245	.087	170	0.080	.086
30–40	142	0.306	0.82	140	0.162	.101	140	0.181	.091
40–50	50	0.246	.145	51	0.079	.177	50	0.142	.156
50–60	180	0.289	.073	174	0.200	.086	172	0.135	.083
> 60	519	0.366	.040	592	0.270	.049	489	0.278	.046
MZM									
18–30	155	0.597	.059	149	0.247	.094	149	0.599	.061
30–40	130	0.688	.054	129	0.442	.089	129	0.643	.064
40–50	67	0.676	.076	67	0.231	.145	67	0.553	.098
50–60	131	0.532	.069	131	0.260	.098	131	0.463	.077
> 60	270	0.483	.051	261	0.189	.069	260	0.341	.062
DZM									
18–30	115	0.157	.101	110	0.114	.118	109	0.070	.110
30–40	95	0.054	.112	89	0,164	.126	89	0.215	.117
40–50	60	0.130	.135	60	0.040	.162	60	0.141	.136
50–60	68	0.345	.118	65	0.288	.138	65	0.297	.128
> 60	157	0.126	.084	148	0.115	.091	147	0.145	.087
DZMF[c]									
18–30	270	0.331	.059	254	0.171	.074	254	0.339	.063
30–40	207	0.264	.069	206	0.203	.081	206	0.166	.075
40–50	122	0.307	.090	118	–0.14	.113	118	0.259	.097
50–60	211	0.131	0.72	210	0.076	.079	209	0.089	.075
> 60	453	0.143	.049	430	0.107	.056	430	0.071	.053

[a] polychoric r
[b] asymptotic standard error of the polychoric r
[c] male twins are first in opposite sex dizygotic pairs

were consistently smaller in males, indicating greater dissimilarity in desired body size in men than women.

Finally, for the discrepancy score between the current and desired body size measures, the MZF polychoric correlations are greater than the DZF correlations for all age groups. All age groups have MZ correlations around 0.5 and the DZ correlations range from 0.08–0.28. The MZM correlations are likewise always greater than the DZM, with some greater variability shown in the MZ correlations (0.34–0.65), but with a similar range for the DZ correlations as for the female twins (0.07–0.30).

Further examination of the current body size measure using univariate analyses are presented in graphic form in Figure 1. For women, the ADE and AE models were all significantly better fitting than alternative models, but there was no significant difference in the fit between the ADE and AE models. The AE model was thus chosen as the best fitting model in the interests of parsimony. In contrast, the ADE model was significantly better fitting than the AE model for those males aged 30–40 (χ^2 = 4.39, $p < 0.05$), and the DE model was significantly better fitting for males aged 50–60 (χ^2 = 11.97, $p < 0.001$) and greater than 60 years (χ^2 = 9.45, $p < 0.005$). In the remaining two age groups the AE model does not give a significantly worse fit than the ADE model and thus was chosen as the most parsimonious model. In all age groups, with the exception of the men aged more than 60 years, the genetic influences accounted for more than 50% of the variance of individual variation.

Turning to the univariate analyses of the desired or ideal body size, where the proportions of variance are summarised in Figure 2, it is immediately obvious that environmental influences play a much more sizeable role in determining individual differences than with estimations of current size. The contribution of the environment ranges from 56% (women aged 40–50 years) to 100% (women aged 30–40 years and men aged 18–30 years) — for these two age groups the CE model was not significantly worse fitting than the ACE model. The patterns tend to be similar across men and women with the non-shared environment playing a large role in determining individual differences in ideal body size right up to older age.

he summary data set was then examined using PROC GLM, and the results are shown in Table 2. There was a significant main effect of zygosity in predicting polychoric correlations between estimated current body size. In this case, the weighted mean polychoric correlation for MZ twins is significantly higher than that for DZ twins (0.63 versus 0.28). In other words, polychoric correlations vary significantly as a function of heritability, with the MZ:DZ ratio suggesting genetic influence on body size estimation.

Prediction of polychoric correlations between desired body size show a significant main effect for zygosity and gender. In addition, there is a significant interaction between zygosity and gender. The weighted mean polychoric correlation for women is significantly higher than that for men (0.37 versus 0.21), and significantly higher for

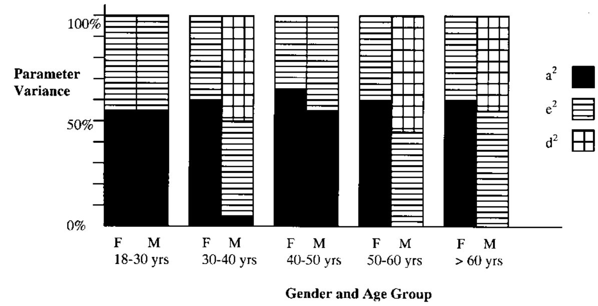

Figure 1

Proportion of variance contributed by each parameter to the estimation of current size — by gender and age group

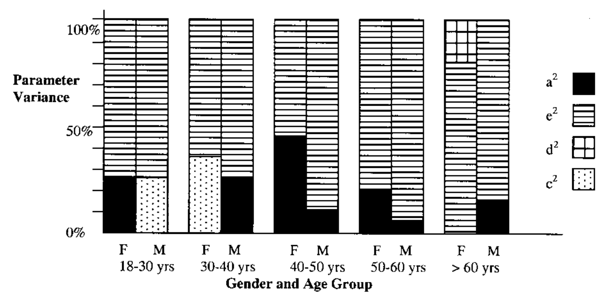

Figure 2

Proportion of variance contributed by each parameter to the estimation of ideal size — by gender and age group

Table 2

Factorial Analysis of Variance

Independent Variables	Current Body Size Type III SS	*F*(*p*)	Desired Body Size Type III SS	*F*(*p*)	Body Dissatisfaction Type III SS	*F*(*p*)
Gender	6.95	4.30 (.11)	12.21	22.88 (.009)	0.02	0.02 (.88)
Zygosity	127.78	78.97 (< .001)	26.77	50.16 (.002)	85.82	134.84 (< .001)
Agerange	1.63	0.25 (.90)	1.28	0.60 (.68)	2.70	1.06 (.48)
Gender x Zygosity	1.38	0.86 (.41)	4.28	8.02 (.047)	0.12	0.19 (.68)
Gender x Agerange	3.54	0.55 (.71)	5.99	2.81 (.17)	8.81	3.46 (.13)
Zygosity x Agerange	8.70	1.34 (.39)	5.34	2.51 (.20)	9.64	3.79 (.11)

MZ twins than for DZ twins (0.41 versus 0.17). Women are therefore more likely to choose a similar desired body size than are men, with high heritability in females and little heritability for men.

Finally, prediction of resemblance in body size dissatisfaction appears to be similar to the current body size estimation in that it is only significantly predicted by zygosity. Weighted mean polychoric correlations for MZ twins (0.53) is significantly higher then the mean for DZ twins (0.17). As with estimated body size, polychoric correlations vary significantly as a function of heritability, with the MZ:DZ ratio suggesting genetic influence on the discrepancy between current and ideal size.

Discussion

Although there have been a number of twin studies on body mass index (BMI), this is the first large-scale, population-based twin study to explore the genetic epidemiology of a commonly used measure of body image. The finding that genetic factors are important in the individual variation in estimated current body size is consistent with the literature on the heritability of BMI. Previous research from twin and adoption studies has concluded that the majority of the variance for weight is accounted for by genetic factors (Plomin et al., 1997). A review of the literature on the familial resemblance of BMI found that twin studies suggest between 50 to 90% of the variance in BMI is accounted for by genetic factors (Maes, 1997). The data presented here are part of a larger data set, where analysis of the weighted mean correlations of the BMI for MZ twins, DZ twins, siblings, parent-offspring pairs, adoptive relatives and spouses has been completed. Results suggested that 67% of the variance of BMI in males and females was due to genetic factors (Maes, 1997), with half of this genetic influence due to dominance. The similarities between the findings of the BMI data and our current study suggest that estimation of current body size using figural stimuli is a procedure that fairly accurately depicts actual body size.

Previous studies of BMI have suggested that the genetic influences on current body size changes with age. A longitudinal study of 4000 pairs of twins at 20 years and again at 45 years (Stunkard, 1986) showed that about 25% of the genetic effects at age 45 were different from genetic effects at age 20. Dominant and additive genetic effects were found to explain the variance in BMI of a younger Australian (female and male) twin sample, whereas only additive genetic effects were relevant for the older group of twins (Neale & Cardon, 1992). While dominance was an important influence on current body size estimation for men, we are unable to make firm conclusions on the role of dominance on women's estimations of their body size due to a lack of power to choose between models. From our current analyses, however, it would seem that the role of dominance differs between BMI and estimations of body size and this may reflect some degree of instability that can be expected to impact on body image measurements.

Our results suggest that the environment, predominantly non-shared between the twin pair, accounts for the majority of the variance observed in measurements of desired body size. Polychoric correlations for this measure vary significantly as a function of gender, with women selecting a more similar desired body size than men. This is consistent with the literature that has documented the existence of environmental pressures on desirable body size, including the thin-ideal body and the centrality of appearance in the female gender-role (Stice, 1994). While this may represent shared environment, in that all women in western culture are exposed to the cultural ideal, it may be that some women are exposed more to this cultural ideal (and subsequently to more criticism about their body size) due to different peer groups, classroom or work environments. The environment is equally important in influencing desired body shape for men, a finding supported by a recent study showing remarkable consistency in the ideal body for men across three countries (Pope et al., 2000). Heritability is also important in influencing the variation in polychoric correlations between desired body size estimations for women whereas there is little influence of heritability in males.

Finally, individual variation in the discrepancy index changes significantly as a function of zygosity (heritability). Taken together with the other findings, these data suggest that traits such as body mass appear to be both heritable and stable across the lifespan. Environmental influences are important in influencing the choice of a desired body size, and for women an "inherited" body shape interacts with these environmental pressures to influence dissatisfaction with their body (if we assume that the discrepancy score reflects dissatisfaction with current size). For example, a genetic tendency that serves to maintain a lean figure throughout the lifetime might be associated with lower overall body dissatisfaction and less change over time. For men, inheritance of a body type does not seem to influence desired body size.

The findings of this study must be interpreted within the limitation of using a twin population. While there is no evidence to suggest that this group of people differ from the general population on adult characteristics associated with one's body (Kendler, 1993), this needs to be investigated further. A more serious potential limitation is our assumption about normality of the sampling distribution for our variables. This is particularly problematic in our analysis of the derived variable, body dissatisfaction, where taking the difference between two bivariately normally distributed ordinal variables created this variable. However, we can not assume that this difference variable is itself bivariately normally distributed, thus possibly constituting a violation of an assumption of twin modelling (Neale & Cardon, 1992). Nonetheless, the polychoric correlations between MZ and DZ twin pairs across age groups provides a meaningful indication of the impact of heritability and gender for these variables.

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