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The genetic epidemiology of body attitudes, the attitudinal component of body image in women

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ABSTRACT

Background. There were four purposes of the current study, including the investigation of the: (*i*) adequacy of a multidimensional measure of body image; (*ii*) genetic and environmental epidemiology of this measure; (*iii*) shared variance between genetic and environmental risk factors for body mass index (BMI) and body image; and (*iv*) Equal Environment Assumption (EEA) as it related to body attitudes.

Method. Six types of body attitudes, as measured by the Body Attitudes Questionnaire (BAQ) and reported by 894 complete female–female twin pairs (mean age 32·35 years, S.D. = 41·8) from the Australian Twin Registry, were analysed.

Results. Confirmatory factor analysis of the BAQ supported the adequacy of the measure. Additive genetic and unique environmental influences best accounted for the variance of all six of the BAQ subscales. The relationship between BMI and body attitudes was primarily due to shared genes rather than environment but the majority of genetic and environmental effects on body attitudes were independent of BMI, with the exception of the Feeling Fat subscale, which shared 53% of its genetic risk factors with BMI. One violation of the EEA was suggested, namely similarity of childhood treatment influenced similarity on Lower Body Fatness subscale.

Conclusions. Findings support the notion that: (*i*) body image is a multidimensional concept; (*ii*) it is relatively independent of BMI; and (*iii*) both genetic and non-shared environment are influential determinants of body attitudes.

INTRODUCTION

Body image, defined as 'the picture we have in our minds of the size, shape and form of our bodies, and our feelings concerning characteristics and our constituent body parts' (Slade, 1988), is viewed as a complex, multidimensional construct containing both cognitive (attitudinal) and affective components (Dorian & Garfinkel, 2002). We live in a culture saturated with representations of the female body and those representations commonly portray bodies whose shape, size and overall presentation are functionally unobtainable in everyday life (Nemeroff *et al.* 1994). It is, therefore, not surprising that many authors have linked poor body image, or what has been eloquently described as the 'normative discontent' (Rodin *et al.* 1985) that many women hold in relation to their own bodies, to contemporary social and inter-personal influences.

However, an increasing body of evidence, in the form of five twin studies of body image (summarized in Table 1), suggests that there is a sizeable genetic contribution to development of body image in women, and in some cases represents the major influence. Of the number of measures that exist to assess the phenotype of body image (Dorian & Garfinkel, 2002), three

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Table 1. *Summary of twin studies examining body image and attitudes in women*

Authors/Year	Female pairs (MZ/DZ) *N*	Measure	Variance A	Variance C	Variance E
Holland *et al.* 1988*	45 (25/20)	EDI	98	0	2
Rutherford *et al.* 1993†	246	EDI – BD	52	0	48
	(147/99)	EDI – DT	44	0	56
Wade *et al.* 1998†	174	EDE – Weight Concern	0	52	48
	(119/55)	EDE – Shape Concern	62	0	38
Klump *et al.* 2000*a*‡	340 11-years	EDI – BD	45	6	50
	(205/135)	EDI – DT	12	30	58
	301 17-years	EDI – BD	63	0	37
	(196/105)	EDI – DT	54	0	46
Wade *et al.* 2001§	5325	FRS – current body size	54–65	0	35–46
	(1751/1068)	FRS – desired body size	20–44	0–34	56–80

* Ascertained population and no correction for ascertainment made in analyses.
† Volunteer twin registry.
‡ Population-based twin registry; a revised version of the EDI was used.
§ Mixture of volunteer and population-based twin registry reporting over five age groups.
EDI, Eating Disorder Inventory; BD, Body Dissatisfaction; DT, Drive for Thinness; EDE, Eating Disorder Examination; FRS, Figure Rating Scale.

have been examined in twin studies. The first is the body dissatisfaction (BD) and Drive for Thinness (DT) subscales of the Eating Disorder Inventory (EDI) (Garner *et al.* 1983). The second is the shape and weight concern subscales of the Eating Disorder Examination (EDE) (Fairburn & Cooper, 1993), and the third is the Figure Rating Scale (FRS) (Stunkard *et al.* 1983). The most commonly examined measure of body image in twin studies is the EDI, with estimates of heritability of around 50% for BD (with the remainder of the variance made up of non-shared environment), and a suggestion that the heritability increases over adolescence. DT appears to have a slightly lower heritability than BD (however lack of reporting of 95% confidence intervals makes direct comparison of studies difficult), with shared environment making a major contribution to the variance pre-adolescence. Supporting the heritability of DT, findings from a family study (where at least one relative pair was affected with anorexia nervosa) indicated that the strongest linkage signal was identified when DT was included in the analysis (Grice *et al.* 2002). One study has suggested that the relationship between body mass index (BMI) and body attitudes is primarily mediated through genes rather than the environment (Klump *et al.* 2000*a*). However, the authors concluded that the majority of genetic influences on eating attitudes were due to genetic effects that were independent of those operating in BMI. Two studies have found a sizeable contribution of the shared environment to body image in adult women, with respect to both weight concern and desired body size, while the majority of the variance for shape concern and current body size is accounted for by additive genetic action. Given that body image is a multidimensional concept, it is not surprising that different genetic and environmental estimations of variance for different measures have been obtained to date.

Twin studies in the eating disorder arena have attracted criticism from various quarters, focusing on four main issues. The first is the lack of power of many twin studies to be able to accurately estimate heritability (Striegel-Moore & Cachelin, 2001). Certainly all but one of the twin studies examining body image have utilised relatively small sample sizes, and are therefore likely to be underpowered. The second criticism is that there has been a lack of adequately measured phenotypes (Fairburn *et al.* 1999). While body image studies do tend to use well validated measures, the only large study uses a one-item measure (the FRS), which is unlikely to be considered an adequate measure of the multi-dimensional nature of body image (Dorian & Garfinkel, 2002). A third criticism focuses on a lack of investigation of possible violations of the Equal Environments Assumption (EEA).

If the EEA is violated (i.e. when more similar treatment of monozygotic (MZ) compared to dizygotic (DZ) twins has an effect on twin similarity for the phenotype), estimates of heritability will be inflated (Bulik *et al.* 2000). Given that possible violations of the EEA have been detected with respect to bulimia nervosa (Hettema *et al.* 1995; Bulik *et al.* 1998), it is important that potential violations of the EEA be addressed in future studies of body image. To date, this potential violation of the EEA has only been investigated in one study of body image where no violations were detected (Klump *et al.* 2000*b*). A final criticism addresses the lack of attention to how genes might influence eating attitudes (Polivy & Herman, 2002). To date, only one measure of body image (the EDI) has been examined with respect to how genes might influence eating attitudes, that is, through the mechanism of body mass index.

We therefore report a study of the genetic epidemiology of body related attitudes in a large sample of Australian adult female twins, addressing some of the criticisms of previous studies. There are four purposes of the current report. The first is to investigate the adequacy of a measure of body image, the Body Attitudes Questionnaire (Ben-Tovim & Walker, 1991), using confirmatory factor analysis. The second purpose is to examine the contribution of genetic and environmental influences in this population on the six body attitudes measured by the BAQ. Thirdly, we investigate how genes might influence body attitudes, by using a multivariate examination of the shared genetic and environmental risk factors for self-reported BMI and body attitudes. Finally, we test two aspects of the EEA as it relates to body attitudes in adult women, co-socialization and childhood treatment.

METHOD

Participants

The data are from female twins from the volunteer National Health and Medical Research Australian Twin Registry. Twins were approached to participate if they were born between 1951–1969. Of 3090 twins approached to participate in the study, 2138 (69%) returned questionnaires. This sample contained responses from 884 complete pairs, of which 527 pairs (60%) were MZ and 357 pairs (40%) were DZ. The mean age of the twins at the time of completing this questionnaire was 32·35 years (S.D. = 4·18), with ages ranging from 26 to 44 years. The majority of the women had completed primary education (99·01%), where 1162 (65%) had completed at least 5 years of secondary education and 420 (24%) had completed a university degree. Four hundred and sixty-three women (26%) indicated that they had never been married, 1183 (66%) indicated that they were married or living as though married and 139 (8%) were either widowed, divorced or separated. In terms of country of birth, 828 (92·6%) of the twin pairs were born in Australia and 698 (78·1%) mothers and 676 (75·7%) fathers were born in Australia.

All twins answered standard zygosity self-report questions that ask about physical resemblance and mistaken identity that have >95% accuracy (Eaves *et al.* 1989). Answers to these questions were used to assign zygosity. Members of a subsample of 198 same-sex pairs from this group, who reported themselves to be MZ, were typed for 11 independent highly polymorphic markers in the course of an asthma study (Duffy, 1994). No errors in previous zygosity diagnosis were detected.

Instruments

The primary instrument used in the current study was the Body Attitudes Questionnaire (BAQ) (Ben-Tovim & Walker, 1991). The BAQ, a self-report instrument measuring body image (Dorian & Garfinkel, 2002), contains 44 items using self-referent statements with a 5-point Likert response scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Nine of the items require reverse scoring. A previous factor analysis of the items suggested six subscales, namely Feeling Fat, Body Disparagement, Strength and Fitness, Salience of Weight and Shape, Attractiveness and Lower Body Fatness (Ben-Tovim & Walker, 1991). The BAQ has been shown to be psychometrically valid in both an Australian and Samoan population of women (Wilkinson *et al.* 1994). The scale also distinguishes women with an eating disorder from a normative population and groups of psychiatrically and physically ill patients (Ben-Tovim & Walker, 1992). It also has been shown to predict treatment outcome (Ben-Tovim *et al.* 2001) for both anorexia nervosa and bulimia nervosa, where greater feelings of attractiveness 6 months after initial contact with a treatment provider predicted better eventual outcome. Interestingly, for patients with bulimia nervosa, the intensity of their feeling of fatness when initially assessed was predictive of their overall outcome, while for patients with anorexia nervosa, the change in salience of weight and shape in the first 6 months of care was of predictive importance.

In addition to an investigation of body attitudes, self-reported BMI was also utilized in the current report. Written informed consent was obtained before completion of the questionnaires.

Statistical analysis

Confirmatory factor analysis

Given that the factor structure of the BAQ has been investigated previously (Ben-Tovim & Walker, 1991), it was decided to perform a confirmatory factor analysis (CFA) on the twin data. We conducted a separate CFA on the Twin 1 data and the Twin 2 data by using two correlation matrices for all items, generated by PRELIS2, which were then examined in a CFA using Lisrel8 (Jöreskog & Sörbom, 1996). The twin design is an ideal vehicle for testing the generalizability of the structure of a measure because the inherent matched pair nature of the data allows results to be compared across the two populations (Twin 1 and Twin 2). No distinction was made between MZ and DZ twins for the purpose of the CFA, as this would not be expected to exert an effect on the outcome. The *a priori* model specified for each twin group was based on the latent variables derived previously from exploratory factor analysis. Evaluation of goodness-of-fit was carried out using two indicators. The first was the Tucker–Lewis or non-normed fit index (NNFI) (Tucker & Lewis, 1973), a statistic that is relatively free from sample size contamination and imposes an appropriate penalty function for the inclusion of additional parameters (Ferguson *et al.* 1994). The second goodness-of-fit statistic was the comparative fit index (CFI) (Bentler, 1990), an unbiased counterpart of the fit index originally proposed by Bentler & Bonett (1980). The CFI evaluates the adequacy of the specified model in relation to the baseline model (the null model), which specifies no relationship among the observed variables, i.e. every item is an indicator of a separate latent variable (Feldman, 1993). For both the NNFI and CFI, the fit coefficients range from 0 to 1, with higher values indicating greater fit: a value of $\geqslant 0{\cdot}9$ indicates that the hypothetical model fits the data well (Marsh, 1991; Feldman, 1993).

Twin analyses

First, in order to examine the correlations between each twin (cross-twin) and each variable (cross-trait), the raw data was analysed using maximum likelihood estimation with Mx (Neale, 1997). Secondly, in order to examine the sources of individual difference of these scales, PRELIS2 (Jöreskog & Sörbom, 1996) was used to produce two 2×2 variance–covariance matrices (one for MZ and one for DZ twins) for each scale. These matrices were then subjected to univariate model fitting using Mx (Neale, 1997). Given that previous examinations of body image have implicated three different influences (additive genes (A), common or shared environment (C) and non-shared or unique environment (E)), the full ACE model was first fitted to the data, followed by an AE, CE and E model. The goal of model fitting is to explain the observed data as an optimal combination of goodness-of-fit and parsimony. Where a model is not significantly worse fitting than the full model (as calculated by the difference between the χ^2(df) for these two models), the Akaike's Information Criterion (AIC) (Akaike, 1987) is used to select the most parsimonious model, where the smaller (or more negative) the value, the better the fit of the model. As the final part of this procedure, the proportion of variance contributed by additive genetic action (a^2), shared environment (c^2) and non-shared environment (e^2) was estimated, along with 95% confidence intervals.

Thirdly, a Cholesky decomposition multivariate model (Neale & Cardon, 1992) was fitted to the BMI data and six BAQ subscales. The main focus of these analyses was to examine the correlation between the phenotypes that can be divided into that due to the different latent influences described above.

Table 2. *Descriptive statistics for the BMI and the item means and standard deviations for the BAQ*

Variable	Mean (S.D.) Twin 1	Mean (S.D.) Twin 2	Cronbach's α Twin 1	Cronbach's α Twin 2
Body mass index	23·58 (4·24)	23·67 (4·45)	—	—
Feeling Fat	3·01 (0·86)	3·03 (0·85)	0·93	0·93
Body Disparagement	1·78 (0·54)	1·80 (0·55)	0·77	0·78
Strength and Fitness	3·26 (0·66)	3·26 (0·62)	0·79	0·75
Salience of Weight and Shape	2·48 (0·64)	2·51 (0·63)	0·75	0·75
Attractiveness	3·41 (0·58)	3·39 (0·61)	0·68	0·71
Lower Body Fatness	3·09 (0·92)	3·10 (0·91)	0·72	0·73

Equal environment assumption

We used polychotomous linear regression to evaluate the equal environment assumption (EEA). There were two regressions for each of the six BAQ scales. In each case, the dependent variable was the absolute value of the difference between the BAQ scales for Twin 1 and Twin 2. The independent variables were zygosity and, in turn, two measures of specified common environment. These measures of common environment were factor scores from five questions of environmental similarity asked of all twins, forming two factors. The first was called co-socialization, reflecting the how much time the twins spent together during childhood (same class and sharing recreational and sporting activities). The second environmental similarity variable was called childhood treatment, examining how similarly the twins were treated as children by their parents, and includes three items (sharing the room, the same playmates and being dressed alike).

RESULTS

Structure of the BAQ in the twin population

The model that was tested for fit contained all six factors previously identified through exploratory factor analysis (Ben-Tovim & Walker, 1991). For both the groups (Twin 1 and Twin 2), this *a priori* model had a NNFI of 0·80 and a CFI of 0·81. Modification indices suggested that the largest improvement to the chi-square statistic would be achieved by moving one item ('if I catch a glance of myself in a mirror or a shop window it makes me feel bad about my shape') from the Body Disparagement subscale to the Feeling Fat subscale. This resulted in an improvement of both fit statistics, yielding a NNFI of 0·82 and a CFI of 0·83. In neither population did any further changes to the model lead to an improvement in the fit statistics. Therefore, all further analyses used this slightly revised form of the BAQ.

Table 3. *Maximum likelihood estimate cross-twin, cross-trait correlations between BMI and BAQ measures: Feeling Fat (FF), Body Disparagement (BDP), Strength and Fitness (S&F), Salience of Weight/Shape (SWS), Attractiveness (A) and Lower Body Fatness (Lower) (twin pair correlations are in bold type)*

Variable	BMI	FF	BDP	S&F	SWS	A	Lower
	MZ twin pairs – Twin 1						
Twin 2							
BMI	**0·72**	0·43	0·21	−0·05	0·14	−0·17	0·28
FF	0·43	**0·55**	0·31	−0·18	0·35	−0·21	0·40
BDP	0·18	0·31	**0·39**	−0·25	0·23	−0·25	0·29
S&F	−0·04	−0·15	−0·19	**0·40**	−0·17	0·17	−0·12
SWS	0·16	0·37	0·21	−0·07	**0·39**	−0·11	0·30
A	−0·10	−0·22	−0·34	0·19	−0·13	**0·47**	−0·15
Lower	0·27	0·42	0·26	−0·16	0·32	−0·16	**0·53**
	DZ twin pairs – Twin 1						
Twin 2							
BMI	**0·39**	0·24	0·13	−0·18	0·10	−0·06	0·14
FF	0·19	**0·17**	0·11	−0·17	0·16	−0·16	0·13
BDP	0·16	0·09	**0·14**	−0·15	0·09	−0·14	0·10
S&F	−0·07	−0·06	−0·06	**0·18**	−0·06	0·20	−0·17
SWS	0·10	0·15	0·08	−0·08	**0·20**	−0·16	0·15
A	−0·13	−0·13	−0·14	0·20	−0·14	**0·23**	−0·10
Lower	0·08	0·13	0·06	−0·06	0·18	0·12	**0·18**

Descriptive analyses

The means, standard deviations and internal consistency (Cronbach's α) for each variable are reported in Table 2. The normality of each scale for both Twin 1 and Twin 2 was investigated, as was the self-reported BMI. Body Disparagement and BMI were severely positively skewed, Salience of Weight and Shape was moderately positively skewed and the Attractiveness subscale was moderately negatively skewed. Appropriate transformations were therefore carried out on these variables.

Cross-twin, cross-trait correlations

The cross-twin, cross-trait correlations are reported in Table 3. The cross-twin correlations for MZ twins are generally twice as much as the DZ twins for each variable. The within-twin,

Table 4. *Results of fitting univariate genetic (A) and environmental (shared: C and non-shared E) models for variation to the BAQ scales and BMI (the best-fitting and most parsimonious model is in bold type)*

Variable	Model	Standardized parameters (×100) with 95% CI			Fit functions				
		a^2	c^2	e^2	χ^2 (df)	*P*	AIC	χ^2_{diff}	*P*†
BMI	ACE	68 (50–75)	4 (0–20)	28 (25–33)	5·32 (3)	NS	−0·68	—	
	AE	72 (68–75)	—	28 (25–32)	5·49 (4)	NS	−2·51	0·17	NS
	CE	—	57 (53–62)	43 (38–47)	78·16 (4)	***	70·16	72·84	**
Feeling Fat	ACE	53 (44–59)	0 (0–8)	47 (42–53)	5·91 (3)	NS	−0·09	—	
	AE	53 (47–59)	—	47 (42–53)	5·91 (4)	NS	−2·09	0 (1)	NS
	CE	—	39 (34–45)	61 (55–66)	49·65 (4)	***	41·65	43·74	**
Body Disparagement	ACE	37 (22–44)	0 (0–13)	63 (56–70)	1·41 (3)	***	−4·59	—	
	AE	38 (31–44)	—	62 (56–70)	1·41 (4)	NS	−6·59	0 (1)	NS
	CE	—	29 (23–35)	71 (65–77)	16·31 (4)	***	8·31	14·90	**
Strength and Fitness	ACE	39 (18–46)	0 (0–18)	61 (55–68)	4·26 (3)	NS	−1·74	—	
	AE	39 (32–46)	—	61 (55–68)	4·26 (4)	NS	−3·74	0 (1)	NS
	CE	—	31 (25–37)	69 (63–75)	16·41 (4)	***	8·41	12·15	**
Salience of Weight/Shape	ACE	39 (17–46)	0 (0–19)	61 (54–68)	0·58 (3)	NS	−5·42	—	
	AE	39 (33–46)	—	61 (54–68)	0·58 (4)	NS	−7·42	0 (1)	NS
	CE	—	31 (25–37)	69 (63–75)	12·03 (4)	*	4·03	11·45	**
Attractiveness	ACE	46 (23–52)	0 (0–20)	54 (48–60)	3·04 (3)	NS	−2·96	—	
	AE	46 (40–52)	—	54 (48–60)	3·04 (4)	NS	−4·96	0 (1)	NS
	CE	—	37 (32–43)	63 (57–68)	19·63 (4)	***	11·63	16·59	**
Lower Body Fatness	ACE	52 (41–57)	0 (0–9)	48 (43–55)	3·13 (3)	NS	−2·87	—	
	AE	52 (45–57)	—	48 (43–55)	3·13 (4)	NS	−4·87	0 (1)	NS
	CE	—	39 (34–45)	61 (55–67)	40·60 (4)	***	32·60	37·47	**

† Obtained by subtracting the χ^2 (df) of the full model (ACE) from the χ^2 (df) of the submodel (AE in each case).
* $P<0·05$; ** $P<0·01$; *** $P<0·001$; NS, not significant.

cross-trait correlations are consistent with relationships shown previously with respect to the BAQ (Ben-Tovim & Walker, 1991). A higher BMI in one twin is correlated in their co-twin with higher levels of feeling fat, greater body disparagement, lower levels of strength and fitness, a higher degree of weight and shape salience, lower levels of attractiveness and a greater perception of lower body fatness. The Feeling Fat scale tends to be the most highly correlated with BMI.

Genetic and environmental influences on BMI and the BAQ scales

Results from model fitting with the BAQ scales and BMI are summarized in Table 4. In all cases a model containing only non-shared environment could be rejected and is therefore not displayed. The best-fitting or most parsimonious model for BMI and all the BAQ subscales is the AE model, with the CE submodel being significantly worse fitting than the full model. With respect to BMI, the majority of the variance is accounted for by additive genetic influences, a finding consistent with a previous examination of self-reported BMI in an older (>30 years) Australian Twin Registry female sample (Martin & Jardine, 1986). The Feeling Fat and Lower Body Fatness subscales had the highest levels of genetic variance, with non-shared environment accounting for the majority of variance in the remaining subscales. There was no overlap in the CIs for genetic or environmental estimations of variance for the Body Disparagement, Strength and Fitness or Salience of Weight and Shape subscales.

Multivariate analysis of BMI and the six BAQ subscales

As the best-fitting univariate models for all variables contained only additive genetic (A) and unique environmental (E) variance, only an AE Cholesky model was fitted to the multivariate data. The fit of this model was good ($\chi^2 = 190·70$ (154), $P = 0·02$, AIC $= -117·30$). Table 5 summarizes the correlations between the additive genetic and unique environmental risk factors for each variable. From the lower

Table 5. *Cholesky decomposition of the genetic and unique environmental correlations* (×100 *with 95% CI*) *between BMI and each of the six BAQ subscales*: *genetic correlations are in the upper half of the table and unique environmental correlations are in the lower half*

Variable	BMI	Feeling Fat	Body Disparagement	Strength and Fitness	Salience of Weight/Shape	Attractiveness	Lower Body Fatness
BMI		73 (67–76)	46 (36–55)	16 (7–25)	37 (27–47)	29 (19–38)	46 (54–39)
Feeling Fat	37 (30–43)		70 (62–78)	39 (39–50)	80 (74–86)	49 (39–56)	77 (72–82)
Body Disparagement	24 (16–32)	50 (44–56)		57 (44–66)	58 (46–68)	70 (79–60)	61 (50–70)
Strength & Fitness	9 (1–18)	17 (9–25)	17 (10–25)		32 (17–45)	48 (60–36)	34 (22–46)
Salience Weight/Shape	15 (7–23)	59 (54–64)	42 (36–49)	9 (1–17)		37 (24–50)	71 (62–79)
Attractiveness	23 (15–31)	29 (21–36)	34 (27–41)	20 (12–28)	12 (4–20)		35 (24–46)
Lower Body Fatness	16 (8–24)	57 (52–60)	28 (21–35)	8 (2–15)	38 (31–44)	17 (9–25)	

bound of the 95% CI it can be noted that none of the genetic or environmental correlations for the bivariate relationships can be constrained to zero. In other words, there are shared sources of genetic and non-shared environmental influence between BMI and the six BAQ measures. The genetic risk factors are correlated more highly for each variable than the environmental risk factor correlations. Consistent with our phenotypic correlations, BMI and Feeling Fat have the highest genetic correlation and also the highest environmental correlation, indicating that these two variables share about 53% of their genetic risk factors and 14% of their non-shared environmental risk factors. Body Disparagement and Lower Body Fatness have the next greatest overlap with the genetic risk factors for BMI (21%), whereas Body Disparagement and Attractiveness share the next highest degree of environmental risk factors at about 5%. With the exception of the shared genetic risk factors between BMI and the Feeling Fat subscale, we find the same as Klump and colleagues (2000*a*): while body attitudes are primarily mediated through genes rather than the environment, the majority of genetic influences on BAQ measures are due to genetic effects independent of those operating in BMI.

Sharing at least 50% of the same genetic risk factors are Feeling Fat with both Salience of Weight and Shape (64%) and Lower Body Fatness (59%): these latter two variables also share 50% of their genetic risk factors. Unique environmental correlations tend to be lower: again the Feeling Fat subscale shares the highest proportion of environmental risk factors with Salience of Weight and Shape (35%) and Lower Body Fatness (33%).

Equal Environment Assumption

Co-socialization (how much time the twins spent together during childhood) and childhood treatment did not predict greater similarity for any of the six BAQ scales, with the notable exception of Lower Body Fatness. Similarity in childhood treatment reported by Twin 1, but not Twin 2, predicted similarity in Lower Body Fatness ratings for co-twins ($t(2, 529) = -2{\cdot}34$, $P = 0{\cdot}02$).

DISCUSSION

The current study utilized a large female twin population in order to investigate the ways in which the development of the attitudinal component of body image can be influenced. There are four aspects of the current research that address previous criticisms of twin studies of female body image. First, our central body image measure of a variety of body attitudes that women can hold in relation to their body was examined in terms of its adequacy. Secondly, we have one of the largest twin samples utilized in an investigation of body image, resulting in sufficient power to obtain narrow estimates of genetic and environmental parameters. Thirdly, we investigate the EEA with respect to a variety of measures of body image. Finally, we investigate how genes might contribute toward the variance of these body image measures by exploring the degree to which BMI shares genetic risk factors with body attitudes.

Measuring the attitudinal component of body image

We were able to investigate further the robustness of a body image measure that has previously been investigated with respect to discriminant validity, the BAQ (Ben-Tovim & Walker, 1991, 1992). In both populations (Twin 1 and Twin 2) we found the structure of the current form of the BAQ to be adequate, but requiring some further improvement with respect to the placement of items in the subscales. Additionally, the internal consistency of the subscales was generally acceptable, with the Attractiveness subscale requiring some further attention to the items included in this subscale. The reasons that the items in the BAQ do not perform as well as a previous investigation of the BAQ validity (Ben-Tovim & Walker, 1991) could relate to the different populations examined. In the earlier study women aged 15 to 65 years were included, whereas the current study included women of a much narrower age range, 26 to 44 years. We conclude that the BAQ is certainly a valid measure of body image but one that requires further investigations with a view to improving its validity.

Genetic and environmental influences on body attitudes

The cross-twin correlations and biometric model fitting suggest that a model containing additive genetic (A) and non-shared environmental (E) influence was the best representation of the variance contributing to all the body image measures. All of the AE models had narrow 95% confidence intervals, suggesting adequate power to accurately assess heritability. The two subscales that measured perceptions of fatness had the highest heritabilities, over 50%, with a lower bound of 45%. The individual variation in the remaining four subscales was best accounted for by unique environmental influences, with an upper heritability estimate of 46%, with the exception of the Attractiveness subscale at 52%. These heritability estimates are slightly lower than previously found with alternative measures of affective body image (Klump *et al.* 2000*a*; Rutherford *et al.* 1993; Wade *et al.* 1998), indicating that different dimensions of body image are differentially affected by genes and the environment. Overall these results are consistent with previous findings of twin studies in suggesting that both the unique environment and additive genetic action have an important role to play in the development of many aspects of body image. In other words, there is consistent evidence for genetic influence on certain measures of body image but such attitudes are also heavily influenced by unique personal experience.

To date the shared environment has been found to be of importance in body image for young adolescents (Klump *et al.* 2000*a*) and in weight concern, a measure of the degree to which self-worth is affected by weight (Wade *et al.* 1998), and desired body size (Wade *et al.* 2001). There is no evidence for a role of shared environment on any of the measures of body related attitudes examined in the current study, with any model containing shared environment being significantly worse fitting than the full model. This may raise some doubts as to whether sociocultural pressures to be thin are the strongest influence on body image (Dorian & Garfinkel, 2002). However, recent thoughtful reviews on the nature of non-shared environment (Klump *et al.* 2002; Turkheimer & Waldron, 2000) stress the importance of effective non-shared environment, where the non-shared effects are defined by the outcomes they produce rather than the objective differential experiences. For example, it may be that sociocultural pressures on body are experienced differently by different siblings as it interacts with genetically influenced temperament or differential experiences when growing up.

Shared genetic and environmental risk factors between BMI and body attitudes

All our measures of body attitudes share some degree of genetic and environmental risk factors with BMI. The Feeling Fat measure shares the largest degree of genetic risk factors with BMI, at 53% with a lower bound of 45%. The remaining subscales do not share the majority of their genetic risk factors with BMI, with overlap ranging from 3% for Strength and Fitness to 21% for Body Disparagement and Lower Body Fatness. Environmental risk factors are shared to a lesser extent with BMI, ranging from 1% for Strength and Fitness to 14% for Feeling Fat. With the exception of the feeling fat scale, our results concur with those of Klump and colleagues (2000*a*) – the relationship between BMI and body attitudes is primarily mediated through genes rather than the environment but the majority of genetic and environmental effects on body attitudes are independent of BMI. The exception to this finding, the Feeling Fat subscale, is an intriguing finding, indicating that some aspects of body image can primarily be influenced by BMI. However, the attitudinal component of the body image can be seen to be largely independent of BMI, and is influenced by genes and specific sources of the environment that have yet to be identified. It is of interest to note that different measures of body image are influenced by different degrees of genetic and environment action, and also differentially influenced by genes and environment acting on BMI. This supports a previous suggestion that body image is a multidimensional concept (Dorian & Garfinkel, 2002).

Feeling Fat is most closely associated with the Salience of Weight and Shape subscale, in terms of both shared genetic and environmental risk factors. High scores on these two measures have been shown to predict poor outcome in bulimia nervosa and anorexia nervosa respectively (Ben-Tovim *et al.* 2001), and may therefore represent different components of a core construct that is important in the maintenance of eating disorders.

Equal Environment Assumption

Our test of the EEA in the six measures of body image, with respect to co-socialization and similarity of childhood treatment, revealed only one violation of the EEA. In other words, co-twin similarity for Lower Body Fatness ratings was influenced by similarity of treatment during childhood. This may explain the different findings with respect to EEA in eating disorder research (Klump *et al.* 2000*b*; Hettema *et al.* 1995; Bulik *et al.* 1998), suggesting that some eating and body measures may be influenced by more similar treatment in childhood. While there is evidence to suggest that such violations do not seriously affect estimations of genetic parameters (Wade & Kendler, 2000), further research examining measures associated with disordered eating should assess for violations of EEA and interpret heritability estimates in this light. Based on our findings with respect to the EEA and the narrow confidence intervals for our parameter estimates, we can suggest that our estimates of genetic parameters are sound for the majority of our body image measures.

Limitations and directions for future study

There are three major limitations of the results reported in this study. The first is that we used a volunteer, not a population based, twin registry. This may indicate that there are biases in the sample used in the current study. While MZ twins tend to be over-represented in volunteer samples (Lykken *et al.* 1978) previous investigations have shown the Australian female twin sample is largely representative of the general female population on a variety of indicators including age, general level of education and marital status (Baker *et al.* 1996). Secondly, we use self-reported BMI rather than experimenter measured BMI, which could introduce some errors into our BMI estimations. However, self-reported weight has been found to correlate well with confederate measured weight, correlated at the 0·96 to 0·99 level (United States Public Health Service, 1988). Finally, we must use caution in the interpretation of the genetic correlations between our measures of body attitudes and BMI. While these inferences are likely to be true, genetic correlations are not always sufficient evidence for this inference (Carey, 1988).

This is the largest and most comprehensive study of the genetic epidemiology of a variety of body related attitudes among women currently available. It demonstrates the importance of genetic factors in the development of those attitudes, and also indicates that the individual experiences of women in relation to their own body powerfully interact with their genetic predisposition (that is largely independent of BMI) in relation to the development of those attitudes. Given the important influence that both genes and the environment play in the development of body image, future research should focus on identifying the complex genetic and environmental interactions that make up the causal pathways to body image (Paykel, 2002), with a focus on specific variables that might interact with genetic susceptibility to produce poor body image. Specific variables worth examining include peer teasing relating to physical characteristics during childhood, cultural influences, media effects, self-esteem and sexual abuse (Dorian & Garfinkel, 2002). Such research will aid us in identifying ways in which we can intervene to protect women against body image problems.

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