



Perceived facial adiposity conveys information about women's health

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Although several prominent theories of human facial attractiveness propose that some facial characteristics convey information about people's health, empirical evidence for this claim is somewhat mixed. While most previous research into this issue has focused on facial characteristics such as symmetry, averageness, and sexual dimorphism, a recent study reported that ratings of facial adiposity (i.e., perceptions of fatness in the face) were positively correlated with indices of poor physical condition in a sample of young adults (i.e., reported past health problems and measures of cardiovascular fitness). These findings are noteworthy, since they suggest that perceived adiposity is a potentially important facial cue of health that has been overlooked by much of the previous work in this area. Here, we show that ratings of young adult women's facial adiposity are (1) better predicted by their body weight than by their body shape (Studies 1 and 2), (2) correlated with a composite measure of their physical and psychological condition (Study 2), and (3) negatively correlated with their trait (i.e., average) salivary progesterone levels (Study 3). Together, these findings present further evidence that perceived facial adiposity, or a correlate thereof, conveys potentially important information about women's actual health.

Facial attractiveness judgements influence a wide range of important social outcomes, including romantic partner and associate choices, hiring and voting decisions, and other types of social interaction and exchange (reviewed in Langlis *et al.*, 2000; Rhodes, 2006). These findings have prompted considerable interest in identifying the factors that influence perceptions of facial attractiveness (reviewed in Rhodes, 2006). Several prominent theories propose that facial attractiveness judgements, at least partly, reflect psychological adaptations that identify healthy individuals (e.g., Little *et al.*, 2011a; Miller & Todd, 1998; Thornhill & Gangestad, 1999). In light of this proposal, many studies have investigated the relationships between facial attractiveness and measures of actual health.

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Early research into the relationships between facial appearance and health measures focused on attractiveness judgements of faces and produced mixed results (reviewed in Coetzee *et al.*, 2009). For example, while some studies reported evidence that more facially attractive individuals actually are healthier (e.g., Hume & Montgomerie, 2001; Shackelford & Larsen, 1999), other studies did not replicate these findings (e.g., Kalick *et al.*, 1998; Thornhill & Gangestad, 2006). Inconsistent results for the relationship between facial attractiveness and health measures might be expected, however, given individual differences in the extent to which people prefer healthy individuals (reviewed in Little *et al.*, 2011a; Tybur & Gangestad, 2011). Consequently, researchers' focus has recently shifted towards exploring the possible relationships between health measures and more specific aspects of facial appearance (Coetzee *et al.*, 2009). To date, the majority of this research has investigated the roles of facial symmetry, averageness (the converse of distinctiveness), sexual dimorphism, and, to a lesser extent, skin condition (see Coetzee *et al.*, 2009).

Although some studies have observed negative correlations between facial symmetry and past health problems (Shackelford & Larsen, 1997; Thornhill & Gangestad, 2006), other researchers have not (Rhodes *et al.*, 2001; Zebrowitz & Rhodes, 2004). Similarly, although some studies have reported negative correlations between women's facial averageness and past health problems (Rhodes *et al.*, 2001; Zebrowitz & Rhodes, 2004), these studies did not observe significant correlations for men's faces. Likewise, while facial masculinity in men is negatively correlated with past health problems (Rhodes *et al.*, 2003; Thornhill & Gangestad, 2006), findings for women's facial femininity are somewhat more mixed, with some studies reporting negative correlations between women's facial femininity and past health problems (Gray & Boothroyd, 2012; Thornhill & Gangestad, 2006), while others have found that these variables were not correlated (Rhodes *et al.*, 2003). While these studies examined past health problems, other work suggests that genetic markers of immunity to infectious disease (i.e., measures of genetic heterozygosity) may be positively correlated with facial averageness in men and facial symmetry in women (Lie *et al.*, 2008). Studies of perceived skin condition have also reported that healthy-looking facial skin is positively correlated with genetic markers of immunity to infectious disease (Roberts *et al.*, 2005) and with consumption of fruit and vegetables (Stephen *et al.*, 2011), suggesting that perceived skin health conveys accurate information about actual health. These findings are consistent with other work suggesting that people with healthy-looking faces (i.e., faces rated as particularly healthy looking by third parties) tend to report a lower incidence of past health problems (e.g., Kalick *et al.*, 1998; Little *et al.*, 2011b). Although experimentally increasing facial symmetry, averageness, and skin health generally increases the perceived health of face images (reviewed in Rhodes, 2006), increasing masculine characteristics in men's faces does not necessarily make them look healthier (Boothroyd *et al.*, 2005; but see Johnston *et al.*, 2001).

While most research exploring the possible links between health measures and specific aspects of facial appearance have focused on the roles of symmetry, averageness, sexual dimorphism, and to a lesser extent, skin condition, a recent study by Coetzee *et al.* (2009) suggested that perceived facial adiposity (i.e., the perception of fatness in faces) is a valid facial cue to health. Ratings of the adiposity of face images were positively correlated with the body mass index (BMI) of the individuals who were photographed and the number of past health problems they reported having had in the previous year (Coetzee *et al.*, 2009). Rated facial adiposity was also negatively correlated with measures of good cardiovascular health (Coetzee *et al.*, 2009) and,

in one other study that examined adiposity ratings of relatively unstandardized face photographs, longevity (Reither *et al.*, 2009). These findings suggest that perceived facial adiposity conveys potentially important information about peoples' health and are consistent with research demonstrating the importance of BMI as a predictor of long-term health outcomes (reviewed in Calle *et al.*, 1999). However, as can be seen from our earlier discussion, findings linking actual health to aspects of facial appearance have not necessarily replicated well across studies. Consequently, the aim of the current work was to test for further evidence that perceived facial adiposity is a valid health cue by investigating the relationships between women's rated facial adiposity and measures of their health.

As Coetzee *et al.* (2009) emphasized, for perceived facial adiposity to be a valid cue of health, it is important to establish the accuracy of ratings of the adiposity of face images. Consequently, we first tested for positive correlations between women's BMI and ratings of the perceived adiposity of their face photographs (Study 1A and Study 1B). Additionally, to investigate whether perceived facial adiposity is correlated more strongly with women's body *weight* than with women's body *shape*, we compared the correlations between women's perceived facial adiposity and BMI and between women's perceived facial adiposity and waist-hip ratio (WHR).

In addition to the correlation between perceived facial adiposity and BMI, Coetzee *et al.* (2009) reported that perceived facial adiposity was positively correlated with reported past health problems and negatively correlated with measures of cardiovascular fitness. To extend these findings linking perceived facial adiposity to measures of actual health, in Study 2, we investigated the relationships between women's perceived facial adiposity and a variety of different health measures (reported past health problems, measures of stress, anxiety and depression, exercise behaviour, fruit and vegetable consumption) that are known to be relatively good predictors of health outcomes (reviewed in Bogg & Roberts, 2004; Idler & Benyamini, 1997; Watson & Pennebaker, 1989). We also used factor analysis to explore the possibility that these variables tap different aspects of health. Because the use of self-report data to explore links between health measures and facial appearance may be affected by social desirability biases (e.g., Scott *et al.*, in press), we controlled for the possible effects of these biases in our analyses.

Finally, in Study 3, we explored the possibility that perceived facial adiposity might be correlated with markers of reproductive health in women. Oestrogen and progesterone levels are positively correlated with women's reproductive health (reviewed in Law Smith *et al.*, 2006; Jasienska *et al.*, 2004). Thus, we investigated the relationships between rated facial adiposity and women's trait (i.e., average) levels of salivary oestrogen and progesterone.

STUDY 1A

The aim of Study 1A was to investigate whether ratings of facial adiposity are better predicted by BMI (a measure of body weight) or WHR (a measure of body shape).

Methods

First, we took full-colour, full-face digital photographs of 101 White women (mean age = 19.74 years, *SD* = 1.82 years), all of whom were undergraduate students at the

University of Aberdeen and who participated in the study in return for course credit. Each woman posed for her photograph with frontal direct gaze and a neutral expression. All photographs were taken under standardized diffuse lighting and against a constant background. Images were masked so that hairstyle and clothing were not visible and were standardized for inter-pupillary distance and position (following, e.g., Coetzee *et al.*, 2009).

Height ($M = 167$ cm, $SD = 5.99$ cm), weight ($M = 65.8$ kg, $SD = 11.2$ kg), waist circumference ($M = 76.5$ cm, $SD = 9.36$ cm), and hip circumference ($M = 99.2$ cm, $SD = 9.27$ cm) were measured from each woman. Following Hughes *et al.* (2004) and Vukovic *et al.* (2010), waist circumference was measured at the narrowest point between the rib cage and iliac crest and hip circumference was measured at the widest point between the waist and thigh. BMI was calculated from each participant's height and weight ($M = 23.8$ kg/m², $SD = 4.30$ kg/m²). Using Bray's (1978) classifications, 15% of the women were in the underweight BMI category (15–19 kg/m²), 56% were in the normal category (20–24 kg/m²), 18% were in the overweight category (25–30 kg/m²), and 11% were in the obese category (>30 kg/m²). None of the women were in the emaciated category (<15 kg/m²). WHR was calculated from each participant's waist and hip circumferences ($M = 0.77$, $SD = 0.05$).

A different group of 160 participants (118 women, 42 men; Mean age = 23.77 years, $SD = 9.31$ years) rated the faces for fatness using a 1 (very underweight) to 7 (very overweight) scale. To avoid rater fatigue (i.e., participants becoming bored with the task of rating 101 individual images), each individual participant rated 40 face images that were randomly selected from the full set of 101 images. Image order was fully randomized and each image remained onscreen until the participant had entered their rating (following, e.g., Coetzee *et al.*, 2009). The rating part of the study was run online, with participants recruited from links on social bookmarking websites (e.g., stumbleupon). Previous studies have shown that online and lab-based studies of face ratings produce very similar patterns of results (e.g., Wilson & Daly, 2004; Senior *et al.*, 1999a, 1999b). The average adiposity rating for each face image was calculated from the ratings and was used in our analyses ($M = 4.12$, $SD = 0.88$).

Results

BMI was positively correlated with rated facial adiposity ($r = .63$, $N = 101$, $p < .001$), as was WHR ($r = .38$, $N = 101$, $p < .001$). BMI and WHR were positively correlated ($r = .36$, $N = 101$, $p < .001$).

Steiger's test (Steiger, 1980) showed that the correlation between BMI and rated facial adiposity was significantly stronger than that between WHR and rated facial adiposity ($z = 2.72$, $p = .007$). A regression analysis with facial adiposity ratings as the dependent variable and both BMI and WHR as predictors showed that both BMI ($t = 6.92$, standardized beta = 0.57, $p < .007$) and WHR ($t = 2.15$, standardized beta = 0.18, $p = .034$) independently predicted women's rated facial adiposity. Including participant age as an additional predictor did not alter this pattern of results. Significant curvilinear relationships between rated facial adiposity and both BMI and WHR (both $p < .001$) indicated that BMI was more strongly associated with facial adiposity among women whose level of facial adiposity was rated as relatively high, while WHR was more weakly associated with facial adiposity among women whose facial adiposity was rated relatively high.

STUDY 1B

Study 1A suggested that ratings of facial adiposity are better predicted by BMI (a measure of weight) than by WHR (a measure of body shape). However, a limitation of Study 1A was that each rater judged only a subset of the images in the study. Consequently, in Study 1B, we sought to replicate the findings from Study 1A using a different sample of women's face images and body measures and a procedure in which all raters judged all of the images for adiposity.

Methods

The procedure used in Study 1B was identical to that used in Study 1A, except that a different group of 50 women (Mean age = 24.3 years, $SD = 4.01$ years) were photographed, a different group of 26 participants (24 women, 2 men; Mean age = 23.2 years, $SD = 8.19$ years) rated the face images for fatness ($M = 3.65$, $SD = 0.89$) and each rater judged the fatness of each of the individual face images, rather than judging only a subset of these images. Inter-rater agreement for adiposity ratings was high (Cronbach's alpha = 0.96). As in Study 1A, measurements of the photographed women's height ($M = 169$ cm, $SD = 6.48$ cm), weight ($M = 57.2$ kg, $SD = 11.4$ kg), waist circumference ($M = 69.6$ cm, $SD = 11.6$ cm), and hip circumference ($M = 94.3$ cm, $SD = 9.53$ cm) were used to calculate their BMI ($M = 20.1$ kg/m², $SD = 3.66$ kg/m²) and WHR ($M = 0.74$, $SD = 0.06$). According to Bray's (1978) classifications, 46% of the women were in the underweight BMI category (15–19 kg/m²), 50% were in the normal category (20–24 kg/m²), 2% were in the overweight category (25–30 kg/m²), and 2% were in the obese category (>30 kg/m²). None of the women were in the emaciated category (<15 kg/m²).

Results

BMI was positively correlated with rated facial adiposity ($r = .66$, $N = 50$, $p < .001$), as was WHR ($r = .46$, $N = 50$, $p = .001$). BMI and WHR were positively correlated ($r = .55$, $N = 50$, $p < .001$).

Steiger's test showed that the correlation between BMI and rated facial adiposity tended to be stronger than that between WHR and rated facial adiposity, though this difference fell just short of significance ($z = 1.86$, $p = .06$). A regression analysis showed that BMI ($t = 4.45$, standardized beta = 0.58, $p < .001$), but not WHR ($t = 1.05$, standardized beta = 0.14, $p = .30$), independently predicted facial adiposity ratings. Including participant age as an additional predictor did not alter this pattern of results. Significant curvilinear relationships between rated facial adiposity and both BMI and WHR (both $p < .002$) indicated that both body parameters were more strongly associated with facial adiposity among women whose level of facial adiposity was rated as relatively high.

STUDY 2

Study 1 suggested that ratings of women's facial adiposity are better predicted by BMI (a measure of weight) than by WHR (a measure of body shape), suggesting that ratings of facial adiposity are somewhat accurate (see also Coetzee *et al.*, 2009). Coetzee

et al. (2009) previously reported that ratings of facial adiposity were also correlated with measures of actual health, such as reported past health problems. Additionally, Reither *et al.* (2009) reported that the rated adiposity of unstandardized face images was negatively correlated with the photographed individuals' longevity. In light of these findings, and because previous findings linking facial appearance to health measures have not necessarily replicated well across studies (see Introduction), Study 2 investigated whether ratings of women's facial adiposity were correlated with self-reported health measures, including past health problems, psychological condition (i.e., stress, anxiety, and depression), exercise behaviour, and consumption of fruit and vegetables. Because these health measures are often inter-correlated (e.g., Watson & Pennebaker, 1989), we used factor analysis to produce health factors that capture different aspects of health.

Methods

The procedures used to collect digital face images and facial adiposity ratings in Study 2 were identical to those used in Study 1A and Study 1B. Here, 50 women were photographed (mean age = 20.30 years, $SD = 2.94$ years) and 21 participants (15 women, 6 men; mean age = 21.90 years, $SD = 5.14$ years) rated each of the face images for fatness ($M = 4.27$, $SD = 0.86$). Inter-rater agreement for these ratings was high (Cronbach's $\alpha = 0.96$). None of the women photographed and none of the raters had taken part in the previous studies.

As in Studies 1a and 1b, measurements of the photographed women's height ($M = 166$ cm, $SD = 5.71$ cm), weight ($M = 64.2$ kg, $SD = 12.7$ kg), waist circumference ($M = 75.1$ cm, $SD = 9.01$ cm), and hip circumference ($M = 95.9$ cm, $SD = 10.3$ cm) were used to calculate BMI ($M = 23.2$ kg/m², $SD = 3.94$ kg/m²) and WHR ($M = 0.78$, $SD = 0.05$). Using Bray's (1978) classifications, 18% of the women were in the underweight BMI category (15–19 kg/m²), 54% were in the normal category (20–24 kg/m²), 22% were in the overweight category (25–30 kg/m²), and 6% were in the obese category (>30 kg/m²). None of the women were in the emaciated category (<15 kg/m²). Factor analysis of BMI, weight, waist circumference, and hip circumference produced a single factor that explained 92% of the variance in the individual measures and with which all the individual measures were positively correlated (all $r > .94$). We labelled this factor *body adiposity*. High scores indicate high levels of body fat.

In addition to being photographed and having body measurements taken, each of the women also completed a series of questionnaires designed to assess various components of health. These components were psychological condition, physical condition, exercise behaviour, and diet (consumption of fruit and vegetables). In addition to the health questionnaires, participants completed Strahan and Gerbasi's (1972) short version of the Marlowe-Crowne Social Desirability Scale, which identifies the extent to which individuals exhibit a social desirability bias.

Women's psychological condition was assessed using the Perceived Stress Scale (Cohen *et al.*, 1983), the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983), the State-Trait Anxiety Inventory (Spielberger, 1968, 1977), and the Brief Profile of Mood States (Cella *et al.*, 1987). Factor analysis of scores on these scales produced a single factor, which explained 66% of the variance in scores and was positively correlated with each of the individual measures (all $r > .76$). We labelled this factor *psychological condition*. High scores indicate poor psychological health.

Women's physical condition was assessed using three scales. The first, the Pennebaker Inventory of Limbic Languidness (Pennebaker, 1982), asks participants to report how regularly they have experienced a range of physical ailments, such as diarrhoea, running nose, and congested nose. The other two scales were versions of the Physical Health Questionnaire (Schat *et al.*, 2005), which asks participants to indicate how many symptoms from a list of ailments, such as nausea, headaches, sleeplessness, and diarrhoea, they have experienced. One version of this questionnaire asked how many of these symptoms participants had experienced in the last year and the other version asked how many of these symptoms participants had experienced in the last 3 months. Factor analysis of the scores on these three scales produced a single factor, which explained 78% of the variance in scores and was positively correlated with each of the individual measures (all $r > .77$). We labelled this factor *physical condition*. High scores indicate poor physical health.

Women's typical exercise behaviour was assessed using two questionnaires. The first was the Godin Leisure Time Exercise Questionnaire (Godin & Shephard, 1997), which produces a single composite score derived from the amount of mild, moderate, and strenuous exercise participants report doing in a typical week. The second was the World Health Organization's Global Physical Activity Questionnaire (<http://www.who.int/chp/steps/GPAQ/>), which produces separate scores for the amount of mild, moderate, and vigorous exercise participants report doing in a typical week. Factor analysis of these scores produced a single factor, which explained 54% of the variance in scores and was positively correlated with each of the individual measures (all $r > .58$). We labelled this factor *exercise behaviour* and high scores indicate a greater amount of exercise reported for a typical week.

We also asked participants how many portions of fruit and vegetables they consumed in a typical day and in a typical week in two separate questions. Factor analysis of these responses produced a single factor, which explained 62% of the variance in scores and correlated highly with both of the individual measures (both $r > .78$). We labelled this factor *diet* and high scores indicate a greater amount of fruit and vegetables consumed.

Results

Following Study 1A and Study 1B, we first tested whether BMI was a better predictor of facial adiposity than was WHR. There was a strong positive correlation between BMI and rated facial adiposity ($r = .68$, $N = 50$, $p < .001$) and a weaker positive relationship between WHR and rated facial adiposity that was not significant ($r = .23$, $N = 50$, $p = .11$). Women with higher BMIs also tended to have higher WHRs, although this correlation was not quite significant ($r = .28$, $N = 50$, $p = .052$).

Steiger's test showed that the correlation between BMI and rated facial adiposity was stronger than that between WHR and rated facial adiposity ($z = 3.13$, $p = .002$). A regression analysis showed that BMI ($t = 6.54$, standardized beta = $.70$, $p < .001$), but not WHR ($t = 0.46$, standardized beta = 0.05 , $p = .65$), independently predicted facial adiposity ratings. Including participant age as an additional predictor did not alter this pattern of results. A significant curvilinear relationship between rated facial adiposity and BMI ($p < .001$) indicated that BMI was more strongly associated with facial adiposity among women whose level of facial adiposity was rated as relatively high. The curvilinear relationship between rated facial adiposity and WHR was not significant ($p = .24$).

Table 1. Correlations among the *body adiposity*, *psychological condition*, *physical condition*, *exercise behaviour*, and *diet factors*. The table also shows the correlations between each of these variables and facial adiposity ratings (top row).

	Body adiposity factor	Psychological condition factor	Physical condition factor	Exercise behaviour factor	Diet factor
Rated facial adiposity	.67***	.29*	.26 [†]	.06	-.05
Body adiposity factor		.22	.09	.01	.06
Psychological condition factor			.50***	.03	-.16
Physical condition factor				.37**	-.19
Exercise behaviour factor					.15

Note. $N = 50$, ***two-tailed $p < .001$, **two-tailed $p < .010$, *two-tailed $p < .050$, [†]two-tailed $p < .10$.

Because there were some relatively strong correlations among the *body adiposity*, *physical condition*, *psychological condition*, *exercise*, and *diet factors* (see Table 1), we entered these variables into a final factor analysis. This analysis produced three factors explaining 34%, 24%, and 21% of the variance in scores, respectively. The correlations between the individual variables and each of these factors are shown in Table 2. The first factor was most highly correlated with *physical condition* and *psychological condition*, so we labelled it the *general condition factor*. The second factor was most highly correlated with *exercise behaviour* and *diet*, so we labelled it the *lifestyle factor*. The third factor was most highly correlated with *body adiposity*, so we labelled it the *measured adiposity factor*.

Rated facial adiposity was positively correlated with scores on both the *general condition factor* ($r = .41$, $N = 50$, $p = .003$) and the *measured adiposity factor* ($r = .51$, $N = 50$, $p < .001$). These two correlations were not significantly different from one another ($z = 0.59$, $p = .56$) and remained significant when we used partial correlation analyses to control for social desirability scores (*general condition factor*: $r = .39$, $N = 50$, $p = .007$; *measured adiposity factor*: $r = .54$, $N = 50$, $p < .001$). The

Table 2. Correlations between each of the initial factors shown in Table 1 and the *general condition*, *lifestyle*, and *measured adiposity factors*. Table 2 also shows the correlations between rated facial adiposity and the *general condition*, *lifestyle*, and *measured adiposity factors* (top row).

	General condition factor	Lifestyle factor	Measured adiposity factor
Rated facial adiposity	.41**	-.04	.51***
Psychological condition	.77***	-.25 [†]	.18
Physical condition	.87***	.10	-.22
Exercise behaviour	.42**	.76***	-.28 [†]
Diet	-.29*	.73***	.39**
Body adiposity	.33*	-.01	.86***

Note. $N = 50$, ***two-tailed $p < .001$, **two-tailed $p < .010$, *two-tailed $p < .050$, [†]two-tailed $p < .10$.

corresponding correlations between the *lifestyle factor* and rated facial adiposity were not significant in either type of analysis (simple correlation: $r = -.04$, $N = 50$, $p = .80$; partial correlation: $r = .01$, $N = 50$, $p = .98$).

A linear regression analysis, in which facial adiposity ratings were the dependent variable and the *general condition*, *lifestyle*, and *measured adiposity* factors were entered as predictors showed significant correlations between rated facial adiposity and scores on both the *general condition* ($t = 3.69$, standardized beta = 0.41 , $p < .001$) and the *measured adiposity* factors ($t = 4.55$, standardized beta = 0.51 , $p < .001$). Rated facial adiposity did not predict scores on the *lifestyle* factor ($t = -0.34$, standardized beta = -0.04 , $p = .74$). Including social desirability scores or participant age as additional predictors did not alter this pattern of results.

Additional analyses revealed significant curvilinear relationships between rated facial adiposity and scores on the *general condition* factor ($p = .010$) and between rated facial adiposity and scores on the *measured adiposity* factor ($p < .001$). These curvilinear relationships reflected the correlation between *general condition* and rated facial adiposity being stronger among women who were given higher ratings for facial adiposity and the correlation between *measured adiposity* and rated facial adiposity being stronger among women who were given lower ratings for facial adiposity. There was no significant curvilinear relationship between rated facial adiposity and scores on the *lifestyle* factor ($p = .95$).

STUDY 3

Study 2 found that perceived facial adiposity was correlated with both a composite measure of women's body fat and composite measures of poor psychological and physical condition. Rated facial adiposity may also be correlated with measures of women's reproductive health, however. Consequently, and because women's oestrogen and progesterone levels are correlated with women's reproductive health (reviewed in Law Smith *et al.*, 2006; Jasienska *et al.*, 2004), Study 3 investigated the relationships between ratings of women's facial adiposity and salivary levels of progesterone and estradiol.

Methods

Forty-nine women (Mean age = 22.1, $SD = 6.81$), none of whom had taken part in any of the previous studies, were photographed in Study 3. The procedures used to collect face images were identical to those used in the previous studies. Face images were rated for fatness ($M = 4.13$, $SD = 1.03$) by 52 raters (38 women, 14 men; Mean age = 23.05 years, $SD = 6.15$ years), using the procedure from Study 1B and Study 2. Inter-rater agreement for these ratings was high (Cronbach's alpha = 0.98).

Each photographed woman provided a saliva sample when she came to the lab to be photographed. Participants also returned an additional three times, at weekly intervals, in order to provide further saliva samples. Participants deposited between 3 and 5 mL of saliva by spitting directly into plastic pharmaceutical vials at the beginning of each testing session. The vials were then sealed and frozen at -20°C .

Hormonal assays were performed by the biological sciences lab at Queen Margaret University College (Edinburgh, UK). Salivary progesterone and oestrogen (as estradiol) levels were assayed using Salimetrics ELISA kits. Briefly, standards, controls and unknown samples in duplicates were pipetted into a micro-titre plate that was previously coated

with rabbit anti-steroid antibody followed by the addition of horseradish peroxidase conjugate. The assays were then completed as described in the kit manual.

Results

Average salivary progesterone ($M = 90.8$ pg/mL, $SD = 64.6$ pg/mL) and estradiol ($M = 11.6$ pg/mL, $SD = 6.57$ pg/mL) levels were calculated for each participant by averaging measures across all four samples. Because visual inspection of scatter plots of these data identified some potential outliers, we controlled for the possible effects of these outliers by using non-parametric tests. There was a significant negative correlation between rated facial adiposity and salivary progesterone ($r_{bo} = -.30$, $N = 49$, $p = .038$). The correlation between estradiol and rated facial adiposity, although also negative, was not significant, however ($r_{bo} = -.18$, $N = 49$, $p = .22$).

There were no significant correlations between age and any of the other variables (rated facial adiposity: $r_{bo} = .18$, $p = .21$; progesterone: $r_{bo} = -.14$, $p = .33$), although older women in our sample tended to have lower estradiol levels ($r_{bo} = -.26$, $p = .07$). Additional tests revealed no significant curvilinear relationships between rated facial adiposity and either salivary progesterone or estradiol (both $p > .15$).

GENERAL DISCUSSION

Consistent with Coetzee *et al.* (2009), we observed relatively strong positive correlations between ratings of women's facial adiposity and their BMI (Studies 1a, 1b, and 2). These findings present new evidence that ratings of women's facial adiposity are somewhat accurate (i.e., are positively related to a measure of women's actual body weight). In these studies, we also extended Coetzee *et al.*'s (2009) findings by demonstrating that ratings of women's facial adiposity were better predicted by their body weight (i.e., BMI) than by their body shape (i.e., WHR). These results are potentially noteworthy, because they suggest that facial adiposity ratings are more closely related to a body parameter that reflects body weight and predicts health outcomes (i.e., BMI) than they are to a body parameter that predicts health outcomes but is a weaker index of body weight (i.e., WHR). Significant curvilinear relationships between rated facial adiposity and BMI in these studies indicated that the correlation between BMI and rated facial adiposity was particularly strong among women who received relatively high facial adiposity ratings. Although there were also some significant curvilinear relationships between rated facial adiposity and WHR, the nature of these relationships was inconsistent across the studies. Reither *et al.* (2009) recently noted that several large longitudinal studies in the social sciences did not collect height and weight data, but that photographs of the participants were often collected or can be obtained retrospectively from high school or college yearbooks. They suggested that adiposity ratings of these face photographs may be used as a proxy measure of participants' body mass. The relationships between BMI and rated facial adiposity in Study 1 and Study 2 present further evidence for the utility of rated facial adiposity as a proxy body mass measure.

In Study 2, we found that women's rated facial adiposity was also correlated with a general condition factor that primarily reflected both a composite measure of reported past health problems and a composite measure of scales assessing aspects of psychological condition (i.e., psychological stress, anxiety, and depression). That these two composite measures were correlated is consistent with previous work reporting strong associations between psychological and physical condition (reviewed in Watson

& Pennebaker, 1989). Interestingly, the correlation between rated facial adiposity and our general condition factor appeared to be particularly strong among women whose facial adiposity was rated relatively high and remained significant when controlling for the possible effects of social desirability biases. These analyses demonstrating relationships between rated facial adiposity and women's general condition complement both Coetzee *et al.* (2009) and other work linking past health problems and stress to aspects of women's facial appearance (e.g., Kalick *et al.*, 1998; Rhodes *et al.*, 2001; Little *et al.*, 2011b). Our findings linking rated facial adiposity to women's general condition are also consistent with work reporting that ratings of facial adiposity are negatively correlated with longevity (Reither *et al.*, 2009). Importantly, additional analyses suggested that the correlations between measured adiposity and rated facial adiposity and between the general condition factor and rated facial adiposity were not significantly different from one another and were also independent. These findings are potentially noteworthy, since they demonstrate that perceived facial adiposity can convey health information that is independent of the information conveyed by body weight alone. Somewhat surprisingly, we found little evidence that ratings of women's facial adiposity were correlated with their exercise behaviour or consumption of fruit and vegetables. However, we suggest this null finding for lifestyle health and facial adiposity should be treated very cautiously, since other work suggests that the effects of lifestyle on women's BMI tend to be more pronounced in older women than they are in relatively young adults (Brown *et al.*, 1998; Guo *et al.*, 1999). While the women in Study 2's lifestyles may not predict their perceived facial adiposity currently, they may do so later in their lives (Guo *et al.*, 2000).

Progesterone and oestrogen are important factors in women's reproductive health (reviewed in Law Smith *et al.*, 2006; Jasienska *et al.* 2004). Consistent with the proposal that women's facial appearance conveys information about health that might be particularly important in mating contexts (Law Smith *et al.*, 2006), we found that ratings of women's facial adiposity were negatively correlated with their trait (i.e., average) salivary progesterone levels. Although the correlation between women's facial adiposity and trait salivary estradiol levels was also negative, this relationship was not significant. These findings complement previous work linking ratings of women's facial attractiveness and health to levels of sex hormones (Law Smith *et al.*, 2006) and suggest that rated facial adiposity may convey information about women's reproductive health.

Although our findings present further evidence that ratings of facial adiposity are both somewhat accurate and correlated with measures of actual health, they do not shed any light on the specific facial characteristics that people use to assess facial adiposity. Coetzee *et al.* (2010) recently reported that both ratings of facial adiposity and BMI were correlated with several facial proportions that can be measured from digital face images, such as width-to-height ratio, perimeter-to-area ratio, and cheek-to-jaw-width ratio, though perimeter-to-area ratio was correlated with BMI in men only. These findings suggest that facial width-to-height ratio and cheek-to-jaw-width ratio may play key roles in perceptions of women's facial adiposity, though it is, perhaps, unlikely that they are the only cues used to judge facial adiposity. Further work exploring the specific facial cues that underpin perceptions of adiposity is likely to provide insight into the characteristics of faces that drive health perceptions.

In addition to exploring the specific facial cues that underpin perceptions of adiposity, a number of other issues relating to perceived facial adiposity also remain to be addressed. For example, while we observed correlations between measures of actual health and perceptions of women's facial adiposity, the neurobiological correlates of these perceptions remain unclear. Thus, we suggest that studies exploring this issue may provide new insights into the neural basis of social judgements, following work

exploring the neurobiological correlates of attractiveness judgements (e.g., Kampe *et al.*, 2001). Additionally, while our studies investigated the correlations between health measures and perceptions of relatively healthy women's facial adiposity, follow-up studies exploring the nature of these correlations in clinical populations (e.g., women with eating disorders) and how such individuals perceive both their own and others' facial adiposity may provide insights into the role of perceived facial adiposity in body image disorders. Finally, given that prior work suggests that individual differences in peoples' concerns about illness and disease are positively correlated with the extent to which obese and unhealthy-looking individuals trigger negative attitudes (Park *et al.*, 2007; Welling *et al.*, 2007), there may well be utility in exploring the role of concerns about illness and disease in individual differences in participants' responses to faces differing in perceived adiposity.

Most previous work that has investigated the proposal that aspects of facial appearance may convey information about actual health has focused on the possible roles of facial symmetry, averageness, sexual dimorphism and, to a lesser extent, skin colour and texture (reviewed in Coetzee *et al.*, 2009). By contrast with this previous work, our studies focused on the possible role of perceptions of facial adiposity, finding that ratings of women's facial adiposity convey information about their actual health, such as their BMI, actual physical and psychological condition, and trait progesterone levels. Along with Coetzee *et al.*'s (2009) and Reither *et al.*'s (2009) recent work, these findings suggest that perceptions of facial adiposity may play an important role in communicating health information to potential mates, competitors for mates, and social partners that has generally been overlooked in previous work in face perception.

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