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Large breasts and narrow waists indicate high reproductive potential in women

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Physical characteristics, such as breast size and waist-to-hip ratio (WHR), function as important features used by human males to assess female attractiveness. Males supposedly pay attention to these features because they serve as cues to fecundity and health. Here, we document that women with higher breast-to-underbreast ratio (large breasts) and women with relatively low WHR (narrow waists) have higher fecundity as assessed by precise measurements of daily levels of 17-β-oestradiol (E2) and progesterone. Furthermore, women who are characterized by both narrow waists and large breasts have 26% higher mean E2 and 37% higher mean mid-cycle E2 levels than women from three groups with other combinations of body-shape variables, i.e. low WHR with small breasts and high WHR with either large or small breasts. Such gains in hormone levels among the preferred mates may lead to a substantial rise in the probability of conception, thus providing a significant fitness benefit.

Keywords: attractiveness; breast size, female beauty; fertility; oestrogen; waist-to-hip ratio

1. INTRODUCTION

Modern male preferences for selected physical traits in females may be an evolutionary adaptation rooted in biology or a cultural effect resulting from the impact of Western media propagating a particular model of female beauty (Yu & Shepard 1998). Western males prefer females with narrow waists and larger breasts (Singh 1993; Henss 2000), but such body shape is not necessarily considered the most attractive in other societies (Yu & Shepard 1998; Marlowe & Wetsman 2001). To argue that male preferences are adaptive, it is necessary to show that preferred traits serve as cues to fecundity or health (Singh 2002) and may contribute to higher reproductive success. Even though in modern societies reproductive success results from multiple factors, the biological basis of female fertility is its important component. Probability of conception in healthy young women depends largely on physiological characteristics of the menstrual cycle. Levels of ovarian steroid hormones produced during cycles are good indicators and predictors of success of pregnancy (Lipson & Ellison 1996). However, it is absolutely critical that the characterization of hormone concentrations be based on measurements made across the entire menstrual cycle (profiles), rather than on arbitrary single day measurements. The aim of this study was to investigate whether women's traits that are considered attractive by men, i.e. relatively larger breasts and lower waist-to-hip ratio (WHR) correspond to higher levels of female reproductive hormones.

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2. MATERIAL AND METHODS

(a) *Subjects*

One hundred and nineteen Polish women between 24 and 37 years of age (mean age 29.9 years, s.d. 3.54 years), who had regular menstrual cycles, did not take any hormonal medication or contraception, had no fertility problems and had not been pregnant or lactating during the six months before recruitment, collected daily, morning saliva samples for one entire menstrual cycle. Mean length of menstrual cycle was 28.4 days (s.d. 3.46 days, range of 22–38 days).

(b) *Anthropometry*

Subjects' body weight, body fat percentage (measured by bioimpedance) and circumferences (measured to the nearest millimetre) of waist, hips, breast and underbreast were measured before and after the cycle of saliva collection. Measurements were taken randomly with the respect to the phase of the menstrual cycle. Arithmetic means of two measurements, taken for each variable before and after the cycle of saliva collection, were used in analyses. Breast size was measured as the largest circumference at the level of the chest. Relative breast size was assessed by the ratio of circumference of the breast to circumference of the underbreast. WHR was assessed by the circumference of the waist divided by the circumference of the hips. To improve their statistical properties (Jasieński & Bazzaz 1999) both ratios were log transformed before correlation analyses.

(c) *Fecundity measures*

Saliva samples from 14 days (reverse cycle day −1 to −14) and 20 days (reverse cycle day −5 to −24) of each cycle were analysed for the concentration of progesterone (P) and 17-β-oestradiol (E2), respectively, by radioimmunoassay. E2 measurements were made using an I-125-based radioimmunoassay kit (no. 39100, Diagnostic Systems Laboratories, Webster, TX, USA) with the following modifications to the manufacturer's protocol to shift the location of the standard curve: standards were prepared in assay buffer and run at six concentrations from 0.33 to 10 pg ml^{-1}. Samples were added in 100 µl amounts together with 200 µl of assay buffer. Antibody was diluted 1 : 4. Labelled steroid was diluted 1 : 3. Antibody and labelled steroid were added to each tube in 100 µl amounts to yield a total reaction volume of 500 µl per tube. Similarly, P measurements were made using an I-125-based radioimmunoassay kit (no. 3400, Diagnostic Systems Laboratories, Webster, TX, USA) with the following modifications: standards were prepared in assay buffer and run at six concentrations from 2 to 200 pg ml^{-1}. Samples were added in 100 µl amounts together with 100 µl of assay buffer. Antibody was diluted 1 : 4. Antibody and labelled steroid were added to each tube in 100 µl amounts to yield a total reaction volume of 400 µl per tube. In both assays, after overnight incubation at 4 °C, 500 µl of second antibody were added to each reaction tube. Reaction tubes were subsequently centrifuged for 45 min; after aspiration of the supernatant, tubes were counted in a gamma counter for 2 min.

Improper collection or loss during the assay procedure resulted in 6.8% of daily samples of E2 and 4.9% samples of P missing in the analyses. Samples from 1844 cycle days were analysed for E2 and from 1588 cycle days for P. Before statistical analyses, cycles were aligned based on identification of the day of the mid-cycle E2 drop (day 0), which provides a reasonable estimate of the day of ovulation (Lipson & Ellison 1996). E2 values from 18 consecutive days of each cycle aligned on day 0 were used in analyses. Because of missing samples, reliable identification of the day of the mid-cycle E2 drop could not be performed for 10 subjects and they were excluded from E2 analyses.

The following measures of fecundity were used in statistical analyses: 'mean E2'; 'mean mid-cycle E2' (mean of days −2 through to +2); 'mean luteal E2' (mean of days 0 through to +8); 'cycle day 0' (E2 value on day 0); 'peak E2' (E2 value on day −1); 'mean luteal P' (mean of last 14 days of the luteal phase); and 'mid-luteal P' (mean of reverse cycle days −5 to −9, representing, in general, days with the highest P concentration).

(d) *Statistical analysis*

Differences in hormonal indices among the study groups were tested in factorial, fixed model two-way ANOVA analyses, with cycle days as one factor in each analysis and group division criterion as the second factor. In two ANOVA analyses we compared groups of women representing top versus bottom quartiles of WHR and top versus bottom quartiles of breast size. The third ANOVA compared four groups, each with a different combination of WHR and breast size ('narrow waist, large breasts', 'narrow waist, small breasts', 'broad waist, large breasts' and 'broad waist, small breasts'). 'Large' and 'small' breasts were defined based on breast to underbreast ratio above average (1.163, range of 1.087–1.272) or below average, respectively. The 'narrow waist' groups included women with WHR below average value (0.726, range of 0.641–0.856) and the 'broad waist' groups included women with WHR above average. Owing to the lack of a statistically significant relationship between hormonal indices and age, body mass index (BMI, calculated as (body mass in kg)/(height in m)^2) and percentage of body fat, these factors were omitted in statistical analyses testing the relationships of breast size and WHR with hormone levels.

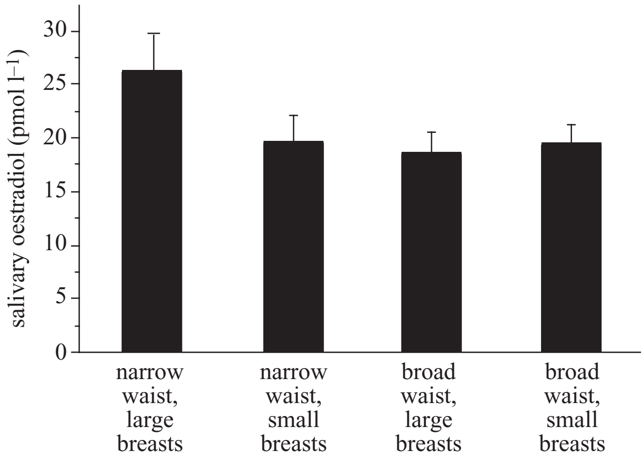

Figure 1. Mean (with 95% confidence interval) mid-cycle E2 in four groups of women with different combinations of WHR and breast size. 'Narrow waist, large breasts' women have higher levels of mid-cycle E2 (Tukey–Kramer with Bonferroni correction, $p < 0.01$) than women from the remaining three groups.

3. RESULTS

The four groups of women with different combinations of WHR and breast size ('narrow waist, large breasts', 'narrow waist, small breasts', 'broad waist, large breasts' and 'broad waist, small breasts') showed significant variation both in mean E2 and mean mid-cycle E2 (two-way ANOVA: $F_{3,1772} = 14.90$, $p = 0.0001$, and $F_{3,507} = 8.66$, $p = 0.0001$, respectively; figure 1). Women from the 'narrow waist, large breasts' group had 26% higher values of mean E2 and 37% higher values of mean mid-cycle E2 than women from any of the other groups (table 1). No significant differences in E2 indices were present among the remaining groups. In addition, the four groups differed in mean P (two-way ANOVA: $F_{3,1520} = 4.423$, $p = 0.004$). The two groups with low WHR had significantly higher P levels than the 'broad waist, large breasts' group (*a posteriori* Tukey–Kramer tests with Bonferroni correction, $p < 0.05$), but all pairwise differences among other groups were not significant.

The results of the four-group comparisons are supported by the evidence of differences in hormonal profiles between top and bottom quartiles of either breast size or WHR. The group of women with larger breasts had a higher mean hormonal profile of E2 than women with smaller breasts (two-way ANOVA with first and fourth quartiles of breast size as one factor: $F_{1,840} = 10.2$, $p = 0.001$; table 2; figure 2*a*). Mean P concentrations were not significantly different between these groups (two-way ANOVA: $F_{1,774} = 9.33$, $p = 0.13$; table 2; figure 2*b*). Women from top and bottom quartiles of breast size had similar mean WHR (*t*-test: $t_{59} = 0.811$, $p = 0.42$).

Similarly, women with narrow waists in relation to hips (low WHR) had a higher mean hormonal profile of E2 compared with women with high WHR (two-way ANOVA with first and fourth quartiles of WHR as one factor: $F_{1,728} = 30.55$, $p = 0.0001$; table 2; figure 2*c*). Moreover, women with low WHR also had a higher mean P profile (two-way ANOVA with first and fourth quartiles of WHR as one factor: $F_{1,776} = 31.4$, $p = 0.0001$; table 2;

Table 1. Body composition, body shape and steroid hormones: four groups.
(Means and s.d. (in parentheses) for four groups of women, each with a different combination of WHR and breast size. E2 is mean of 18 cycle days aligned on day 0, and P is mean of the last 14 days of each cycle. Sample sizes are given in square brackets.)

	BMI (kg m^{-2})	body fat (%)	WHR	breast size	E2 (pmol l^{-1})	P (pmol l^{-1})
all women	22.9 (3.29)	26.7 (7.55)	0.726 (0.049)	1.163 (0.037)	18.1 (8.62) [110]	116.9 (58.36) [119]
narrow waist, large breasts	21.5 (2.41)	24.7 (6.05)	0.689 (0.024)	1.206 (0.036)	21.5 (15.44) [22]	121.6 (99.62) [27]
narrow waist, small breasts	21.3 (2.69)	23.0 (5.96)	0.687 (0.022)	1.143 (0.025)	16.9 (12.63) [33]	124.9 (98.3) [33]
broad waist, large breasts	25.6 (4.9)	31.8 (7.58)	0.774 (0.039)	1.202 (0.039)	17.2 (10.27) [24]	102.4 (72.56) [25]
broad waist, small breasts	23.7 (3.91)	28.0 (7.75)	0.759 (0.034)	1.138 (0.025)	17.1 (11.4) [31]	115.3 (90.73) [34]

Table 2. Body composition, body shape and steroid hormones: low and high WHR, and large and small breasts.
(Means and s.d. (in parentheses) for groups of women tested in two separate ANOVA analyses: comparison of low WHR (first quartile of WHR) with high WHR (fourth quartile) and comparison of large breasts (first quartile of breast size) with small breasts (fourth quartile). E2 is mean of 18 cycle days aligned on day 0, and P is mean of the last 14 days of each cycle. Sample sizes are given in square brackets.)

	BMI (kg m^{-2})	body fat (%)	WHR	breast size	E2 (pmol l^{-1})	P (pmol l^{-1})
low WHR	20.9 (2.02)	22.9 (5.90)	0.669 (0.015)	1.161 (0.036)	20.9 (14.93) [27]	136.8 (108.9) [30]
high WHR	26.5 (5.01)	32.3 (8.65)	0.795 (0.028)	1.166 (0.036)	16.2 (9.71) [27]	102.5 (70.65) [30]
large breasts	23.6 (4.11)	28.9 (7.95)	0.723 (0.048)	1.210 (0.027)	19.4 (14.17) [27]	123.0 (93.06) [30]
small breasts	22.1 (3.0)	25.1 (7.0)	0.732 (0.043)	1.125 (0.017)	16.7 (11.96) [27]	113.0 (93.96) [30]

figure 2*d*). Women from these quartiles of WHR had a similar mean breast size (t-test: $t_{59} = -0.507$, $p = 0.61$).

Further support for the mean-based analyses comes from correlation analyses of mean hormone levels for each woman (computed across her menstrual cycle) with her breast size and WHR. Women with relatively larger breasts tended to have higher E2 levels, as shown by the positive correlation of breast size with mean E2 ($r = 0.203$, $p = 0.03$), mean mid-luteal E2 ($r = 0.194$, $p = 0.04$), mean luteal E2 ($r = 0.204$, $p = 0.03$) and 'cycle day 0' E2 concentration ($r = 0.229$, $p = 0.02$). Similarly, women with relatively narrower waists had higher levels of E2 as shown by correlations of WHR with mid-cycle E2 ($r = -0.231$, $p = 0.01$), 'cycle day 0' ($r = -0.21$, $p = 0.03$) and peak E2 ($r = -0.273$, $p = 0.004$). Those women also had higher levels of P, as shown by significant negative correlations of WHR with mean luteal P ($r = -0.197$, $p = 0.03$) and mean mid-luteal P ($r = -0.233$, $p = 0.01$).

Increase in the probability of conception in the 'narrow waist, large breasts' group relative to other groups was estimated from a logistic regression curve developed for a USA urban population (Lipson & Ellison 1996). In that population, average E2 levels were associated with the probability of conception of *ca.* 12%; a 37% rise in E2 levels led to an increase of probability of conception to *ca.* 35% (i.e. three times). In our study, mid-cycle E2 in the 'narrow waist, large breasts' group was 37% higher than in the other groups, therefore suggesting an approximate threefold increase in the probability of conception.

Breast size did not show significant correlation with WHR ($r = 0.04$, $p = 0.7$). WHR correlated positively with BMI and percentage of body fat ($r = 0.57$, $p < 0.0001$ and $r = 0.49$, $p < 0.0001$, respectively). Breast size correlated with percentage of body fat ($r = 0.21$, $p = 0.02$), but not with BMI ($r = 0.17$, $p = 0.06$).

4. DISCUSSION

To our knowledge, this is the first study that shows that women who are characterized by both a relatively narrow waist and large breasts, i.e. traits considered attractive by

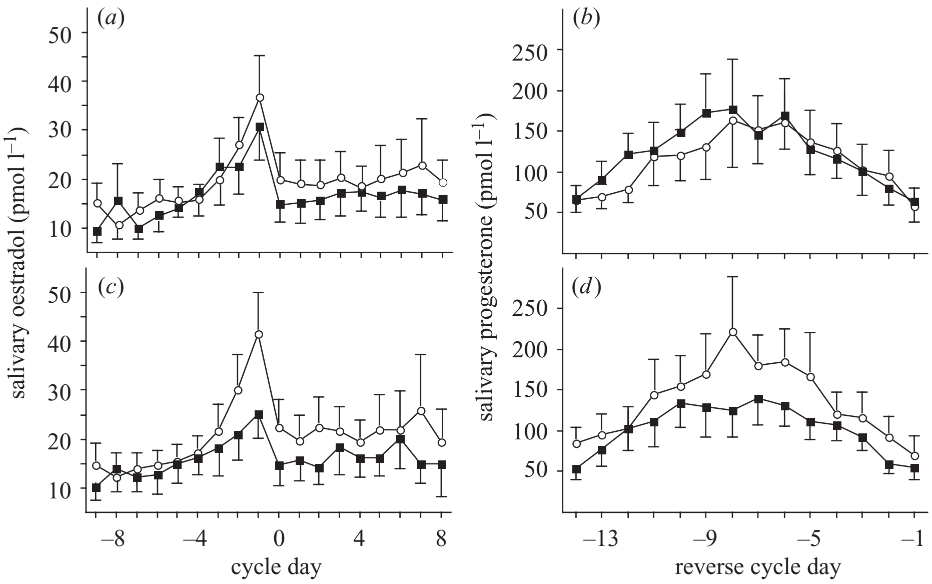

Figure 2. Profiles (daily means with 95% confidence intervals) of (*a*) and (*c*) salivary E2, and (*b*) and (*d*) P, in groups of women with low and high WHRs ((*c*) and (*d*) circles, narrow waist; squares, broad waist) and in groups of women with larger (circles) and smaller (squares) breasts ((*a*) and (*b*)). Daily E2 values were aligned for each cycle on the day of mid-cycle E2 drop (day 0). Daily P values are from the last 14 days of each cycle.

males in Western societies, have higher reproductive potential, as indicated by higher E2 levels and, to some extent, P levels than women with broad waists or small breasts or both. In addition, this study shows that women with larger breasts have higher levels of E2 than women with smaller breasts, independent of WHR. Furthermore, women with low WHRs had higher levels of both E2 and P than women with high WHRs, even though mean breast size was comparable between these two groups. WHR seems to be a better predictor of reproductive potential than breast size, because it correlates both with E2 and P indices, whereas for breast size only its relationships with E2 are significant. Interestingly, a relationship between breast size and E2 may suggest (Pawlowski 1999) that permanent breasts in females could have arisen in the course of human evolution as a side effect of an increase of subcutaneous fat tissue, in which oestrogen played a crucial role.

In previous studies that reported a relationship between WHR and fecundity, women with high WHR were obese (Moran *et al.* 1999) or were patients at fertility clinics (Zaadstra *et al.* 1993). In another study, women with high WHR and classified as obese had higher levels of free testosterone, but did not differ in E2 from women of lower body weight (Evans *et al.* 1983), although it should be noted that in that study the E2 assessment was based on samples taken from a single day of the menstrual cycle. By contrast, in our study all women were healthy, groups with high WHR did not comprise obese women, and hormone profiles were comprehensively assessed by daily sampling across the entire menstrual cycle.

E2 levels correlate with follicle size and with oocyte quality and are related to morphology and thickness of the endometrium (Eissa *et al.* 1986; Dickey *et al.* 1993). Low levels of E2 are associated with diminished penetrability of cervical mucus and poor uterine perfusion, which in turn contribute to reduced fertility (Roumen *et al.* 1982). P is essential for endometrial maturation and a dose–response relationship between P and endometrial secretory transformation had been described (Santoro *et al.* 2000). In the follicular phase of the cycle, P controls granulosa cell proliferation and differentiation (Chaffkin *et al.* 1993). Several studies have reported higher levels of E2, P or both E2 and P in menstrual cycles, which resulted in conception rather than in non-conceptive cycles from the same women (Stewart *et al.* 1993; Lipson & Ellison 1996; Baird *et al.* 1999). An estimation of the effect of the relative difference in E2 levels detected between the group with 'narrow waist, large breasts' and the three other groups on the probability of conception was made based on a previously published study (Lipson & Ellison 1996). The 37% relative increase in mean mid-cycle E2 observed in the 'narrow waist, large breasts' group could be interpreted as indicating that 'narrow waist, large breasts' women would be almost three times as likely to get pregnant as other women. Basing the estimate on the 27% difference in mean E2 indicates that the probability of conception of 'narrow waist, large breasts' women might be enhanced by a factor of two. It is important to note, however, that although these estimates are illustrative and highly relevant, they should be interpreted cautiously, because the prior study (Lipson & Ellison 1996) used data from mid-follicular E2 values to calculate probability of pregnancy, and women participating in that study came from a different population.

Evolutionary biologists disagree about whether the male preference for narrow waists and large breasts is universal across cultures or functions only in industrial societies (Yu & Shepard 1998; Manning *et al.* 1999). In some populations with a more traditional lifestyle males do not seem to show a preference for narrow waisted women (Marlowe & Wetsman 2001). Levels of ovarian hormones in healthy reproductive-age women are very sensitive to the influence of such factors as changes in energy balance (Lager & Ellison 1990; Ellison 2003) or intense physical activity (Jasieńska & Ellison 1998; Jasieńska 2003). Perhaps, in populations where women face severe energetic challenges, such as famine, signals about fecundity provided by body shape have tended to be much less informative for males than those provided by short-term, visible changes in body weight. Weight loss would most probably lead to reduced fecundity regardless of a woman's body shape. That would explain why, in non-industrial populations, women with features indicating good nutritional status, rather than low WHR, are considered most attractive. However, in Western societies, the cultural icon of Barbie as a symbol of female beauty (Rogers 1999) seems to have some biological grounding.

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