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Maternal waist-to-hip ratio does not predict child gender

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It has been suggested that a high pre-conceptual waist-to-hip ratio (WHR) is a good predictor of male offspring and, thus, in cultures that value male children, an androgenous body shape may be judged as most attractive. The predictive value of WHRs is based on studies measuring women who already have children and correlating their WHRs with the proportion of existing male offspring. However, carrying a male child may alter WHRs in a different way to carrying a female child, and a high WHR may be an effect rather than a cause of male offspring. In order to test the predictive power of a pre-conceptual WHR and offspring gender, we took WHR measures from 458 women who intended to become pregnant and then correlated this with the genders of their subsequent children. We found no significant correlation. It is therefore not clear why a high WHR is preferred in some cultures. We suggest that differences in attractiveness preferences between different ethic groups are actually based on weight scaled for height (the body mass index or BMI) rather than the WHR since although there will be a preferred optimal BMI for each ethnic group, which will balance environmental and health factors, this optimal BMI may differ between groups and environments.

Keywords: waist-to-hip ratio; child gender; human mate selection; physical attractiveness; body mass index

1. INTRODUCTION

A number of studies have suggested that Western observers find female bodies with a lower waist-to-hip ratio (WHR) more attractive (e.g. Singh 1993, 1994; Henss 1995; Furnham *et al.* 1997). However, recent studies have suggested that, in some cultures, a higher WHR (a less curvaceous body) is regarded as more attractive (Yu & Shepard 1998, 1999; Wetsman & Marlowe 1999). A possible explanation that has been advanced for this difference is that women with a higher WHR are more likely to give birth to sons and this may be attractive in cultures where male children are valued over female offspring (Manning *et al.* 1996, 1999; Singh & Zambarano 1997).

These reports of a gender difference in offspring are based on measuring the WHR of women with children and correlating this with the proportion of male offspring. However, a number of factors alter the WHR during and after pregnancy relative to the pre-pregnancy WHR. It is well known that there are long-term changes in fat deposition and WHR postpartum, so a WHR measured after pregnancy will be a poor measure of a pre-pregnancy WHR (e.g. Smith *et al.* 1994; Bjorkelund *et al.* 1996). In addition, male babies are significantly larger and heavier than females. This is true throughout pregnancy and at birth (e.g. Weller & Jorch 1993; Lanni *et al.* 1998). Carrying and giving birth to a larger and heavier (male) child may have a significantly greater impact on the subsequent WHR than a smaller and lower weight (female) child. Thus, the results of these gender studies do not differentiate between women with a high WHR giving birth to more sons or more sons producing a higher WHR.

The only way of unambiguously determining whether WHRs do predict the gender of a child is to measure a WHR just prior to conception and then compare this with the gender of the subsequent child.

2. METHODS

In order to determine whether WHRs do predict the gender of a subsequent child, the WHRs of 458 women planning to have children were analysed and compared with the genders of their subsequent children. The women were recruited for an epidemiological study into the factors influencing a healthy pregnancy and successful delivery (Brown *et al.* 1997). The women's age ranged from 22 to 35 years (mean ± s.d. age = 29.5 ± 3.1 years) and they were recruited in the Minneapolis–St Paul area through a health maintenance organization. Women were eligible for the study if they intended to become pregnant within the enrolment period, had not been attempting pregnancy for over three months before enrolment, did not intend to use contraceptive methods during the study, had no history of hypertension, renal disease, diabetes mellitus, heart disease or infertility and submitted a signed consent form (for details of recruitment see Brown *et al.* (1997)). Waist circumference was measured at a level of 1 inch (1 inch = 0.0254 m) above the navel. Hip circumference was measured around the level of the anterior iliac spines. A plot of the pre-conception WHRs of the female volunteers included in this study is shown in figure 1*a*. The women gave birth to live, single children (217 females and 241 males). The average pre-conception WHR of the women giving birth to male children was 0.799 (s.d. = 0.532) and the average pre-conception WHR of women giving birth to female children was 0.800 (s.d. = 0.508).

Our sample size was considerably larger than previously published studies. Previous studies have had sample sizes of 69 women (Singh & Zambarano 1997), 102 women (Manning *et al.* 1996) and 141 women (Manning *et al.* 1999). Thus, our sample

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size of 458 women was up to six times larger than previous studies, all of which claimed to have found an effect. Thus, we might suggest that our sample size was sufficient for producing a significant result if such a trend exists. However, in order to verify this we performed a power calculation. Assuming a significance level of $\alpha = 0.05$ and requiring a power of 0.85 or more, this gave a minimum detectable difference in the WHR of only 0.01.

3. RESULTS

Our results showed no predictive value of the pre-conceptual WHR for child gender. This is illustrated in figure 1*b*, in which a bar graph demonstrates the relationship between the proportion of male children and the pre-conception WHR of the mother. A simple logistic regression showed that pre-conceptual WHRs did not predict the gender of subsequent children ($\chi^2 = 0.030$, d.f. = 1 and $p = 0.861$). As it is possible that maternal age may play a role, we re-ran the regression controlling for age. Again, the result was not significant ($\chi^2 = 0.720$, d.f. = 2 and $p = 0.698$).

Our maternal group contained some women who had already had children prior to this pregnancy and some who had not. It is possible that the predictive effect of a WHR on child gender may vary depending on whether a woman has already given birth. In order to test for this possibility, we analysed the two groups of women separately. There were 161 women who had previously given birth. Within this group, 77 gave birth to male children during the course of this study and 84 gave birth to female children. The average pre-conceptual WHR of the women who gave birth to male children was 0.806 (s.d. = 0.052) and the average pre-conceptual WHR of the women who gave birth to female children was 0.803 (s.d. = 0.045). Our logistic regression showed no significant predictive effect of pre-conceptual WHRs, regardless of whether or not age was controlled for ($\chi^2 = 0.648$, d.f. = 2 and $p = 0.723$, and $\chi^2 = 0.163$, d.f. = 1 and $p = 0.687$, respectively). Out of the remaining 297 women, 296 had not previously given birth and information on prior parity was not available on one woman. Out of the 296 women who had not previously given birth, 163 gave birth to male children and 133 gave birth to female children. The average pre-conceptual WHR of the women who gave birth to male children was 0.797 (s.d. = 0.053) and the average pre-conceptual WHR of the women who gave birth to female children was 0.798 (s.d. = 0.054). Our logistic regression showed no significant predictive effect of pre-conceptual WHRs, regardless of whether or not age was controlled for ($\chi^2 = 1.036$, d.f. = 2 and $p = 0.596$, and $\chi^2 = 0.090$, d.f. = 1 and $p = 0.764$, respectively).

Previous studies have suggested that weight scaled for height (the body mass index or BMI) may be a more important predictor of female attractiveness than the WHR (Tovée *et al.* 1998, 1999, 2000*a*,*b*; Tovée & Cornelissen 2001). BMI is calculated as $\mathrm{kg\,m^{-2}}$ (Bray 1978). We therefore ran a logistic regression in order to determine whether pre-conceptual BMIs predicted child gender for our entire group of 458 women. The average pre-conceptual BMI of the women who gave birth to male children was 22.82 (s.d. = 4.06) and the pre-conceptual BMI of the women who gave birth to female children was 22.92 (s.d. = 4.12). Our logistic regression showed no significant predictive effect of pre-conceptual BMIs, regardless of whether or not age was controlled for ($\chi^2 = 1.250$, d.f. = 2 and $p = 0.536$, and $\chi^2 = 0.231$, d.f. = 1 and $p = 0.631$, respectively).

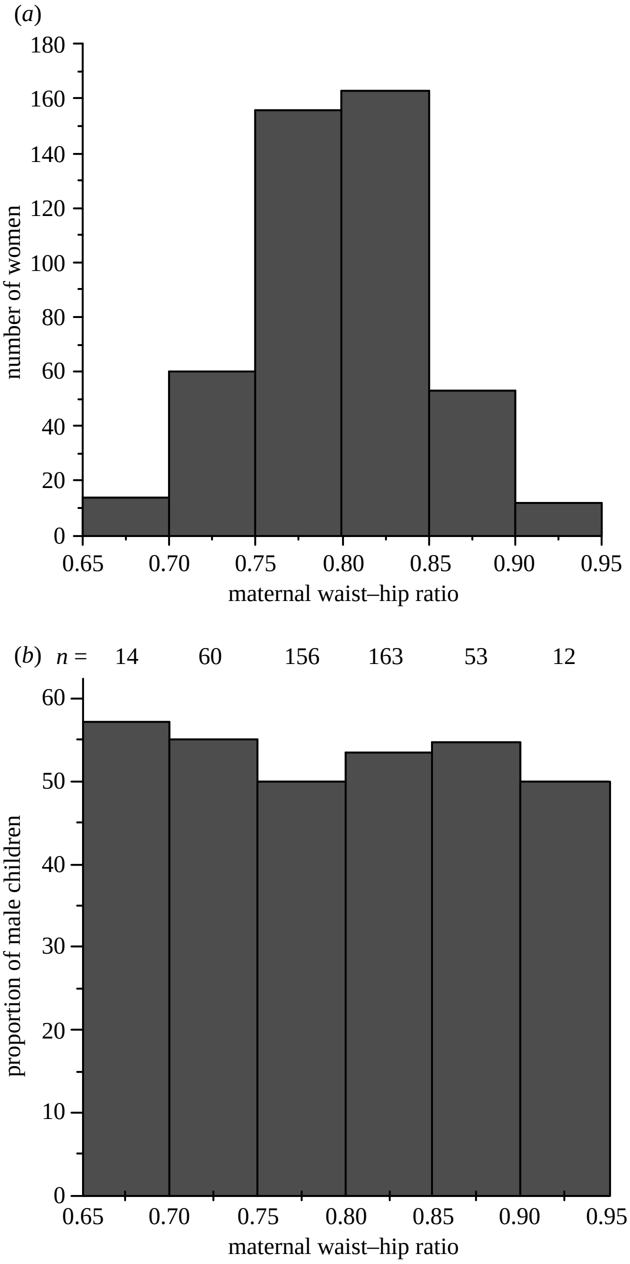

Figure 1. (*a*) A bar graph showing the distribution of pre-conceptual WHR values in our female population. (*b*) A bar graph illustrating the relationship between the proportion of male offspring and the pre-conception WHRs of the mothers. The total number of children for each WHR category is given at the top of the graph. As can be seen, the proportion of male children does not rise with increasing maternal WHR.

4. DISCUSSION

The results suggest that, for this sample of women, pre-conceptual WHR was not a significant predictor of offspring gender. Previous studies, which have measured postnatal WHRs, may have failed to remove possible confounding factors such as the effects of sex differences in birth weight and size (Manning *et al.* 1996, 1999; Singh & Zambarano 1997). Alternatively, it is possible that our result was specific to this group of predominantly Caucasian women and would not apply to different ethnic groups. However, no racial differences have been found in the pattern of increased adiposity and WHR following pregnancy (Smith *et al.* 1994) and the women in one of the previous studies were drawn from a UK population that was also mainly Caucasian (Manning *et al.* 1996), suggesting that ethnic differences cannot easily be invoked as an explanation in this case.

If a high WHR is not a predictor of child gender, then what is the reason for the supposed preference for a higher WHR in some cultures (Yu & Shepard 1998, 1999; Wetsman & Marlowe 1999)? These studies used line-drawn figures that were originally produced by Singh (1993). These line-drawn figures are arranged in three series: underweight, normal and overweight. The BMI of each of the four figures is supposed to be held constant within each series, while the WHR is varied by narrowing the waist. However, this is a false assumption. When the figures are modified by altering the width of the torso around the waist, this not only alters the WHR, but also the apparent BMI. As the value of the WHR rises, so does that of the apparent BMI and, thus, it is not possible to say whether changes in attractiveness ratings are made on the basis of WHR or body mass or both (Tovée & Cornelissen 1999; Tovée *et al.* 1999). Thus, the putative preference changes could be due to changes in body mass preferences rather than WHR preferences (Tovée & Cornelissen 1999).

A multiple regression of the attractiveness ratings for images of real women (who independently vary in their WHR and body mass) suggested that, although both shape and body mass are significant predictors of female attractiveness, weight scaled for height (i.e. BMI) is a far more important factor than the WHR (Tovée *et al.* 1997, 1998, 1999, 2000*a*,*b*; Tovée & Cornelissen 2001). Although these studies used Western observers, it seems likely that different cultural and racial groups would use the same physical parameters in judging attractiveness, although they may have different ideal values for these features.

There are clear advantages to using BMI as a basis for mate selection since BMI is closely correlated with health and fertility. In a recent cohort study, 115 195 women were followed over a 16-year period. The lowest mortality rate (for all causes) was associated with BMIs close to 19 (Manson *et al.* 1995; Willet *et al.* 1995). Although representing the 'normal' range as defined by Bray (1978), women whose BMI fell between 19 and 24.9 had a 20% increase in relative risk of mortality. At still higher values of BMI, the relative risk of mortality accelerated considerably with a 33% increase in relative risk for BMIs of 25–26.9, a 60% increase in relative risk for BMIs of 27–28.9 and a greater than 100% increase in relative risk for BMIs of 29–32. A high BMI also has a negative impact on fertility (Reid & Van Vugt 1987; Frisch 1988; Brown 1993; Lake *et al.* 1997). At the opposite end of the scale, a BMI below 19 has a negative impact on both health and reproductive potential (Reid & Van Vugt 1987; Frisch 1988; Lake *et al.* 1997; Wang *et al.* 2000). Fertility is particularly strongly affected, being reduced to zero at very low BMI levels when women become amenorrhoeic. Thus, although BMI does not predict offspring gender, it is a good cue to a woman's health and fertility and, therefore, a mate choice strategy based on BMI would favour reproductive success.

In the case of BMI, we would not expect the same ideal BMI for health and fertility for all racial groups and all environments. For example, epidemiological studies have suggested that different ethnic populations may have differing levels of risk for negative health consequences with changing body mass (e.g. McKeigue *et al.* 1991; Kopelman 2000). Thus, there may be a different optimal BMI for health and longevity in different racial groups. As a consequence, we suggest that there will be a preferred optimal BMI for each ethnic group, which will balance environmental and health factors, but that this optimal BMI may differ between groups and environments. Thus, an alternative explanation for the supposed cultural differences in preferred WHR would be a difference in preferred BMI based on differences in physiology and environment.

In order to differentiate between these possibilities, preferences for attractiveness in different racial or cultural groups must be tested using a set of images of real women whose BMIs and WHRs vary with a degree of independence, so that the role that WHRs and BMIs play in attractiveness preferences can be assessed independently.

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