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# Watching the Hourglass

## Eye Tracking Reveals Men's Appreciation of the Female Form

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**Abstract** Eye-tracking techniques were used to measure men's attention to back-posed and front-posed images of women varying in waist-to-hip ratio (WHR). Irrespective of body pose, men rated images with a 0.7 WHR as most attractive. For back-posed images, initial visual fixations (occurring within 200 milliseconds of commencement of the eye-tracking session) most frequently involved the midriff. Numbers of fixations and dwell times throughout each of the five-second viewing sessions were greatest for the midriff and buttocks. By contrast, visual attention to front-posed images (first fixations, numbers of fixations, and dwell times) mainly involved the breasts, with attention shifting more to the midriff of images with a higher WHR. This report is the first to compare men's eye-tracking responses to back-posed and front-posed images of the female body. Results show the importance of the female midriff and of WHR upon men's attractiveness judgments, especially when viewing back-posed images.

**Keywords** Attractiveness · Waist-to-hip ratio · Eye tracking · Buttocks · Breasts · Sexual selection

Human sexual attractiveness is often described as unique, complex, and thus exceedingly difficult to quantify. However, men and women across cultures state that physical attractiveness is an important trait in a potential partner (Buss 1989). Morphological traits may be, by their very nature, more accessible to measurement than some other qualities of sexual attractiveness, such as charm or sense of humor. Morphology that conveys biological information relating to health and fertility may be of particular importance when people select their sexual partners (Grammer et al.

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2003). These processes of mate choice may be very ancient and represent the effects of selection on cognitive processes within ancestral human populations (Buss 2003).

In comparison to nonhuman primates, female humans have much larger stores of body fat in their breasts, hips, thighs, and buttocks (Dufour and Slather 2002). Body composition is sexually dimorphic. Men tend to have a more mesomorphic muscular physique, whereas women have larger stores of body fat (Carter and Heath 1990; Clarys et al. 1984; Wells 2007). Sexual dimorphism in body composition is reflected in sex differences in body shape. At puberty, under the actions of estrogens, female body fat is stored around the hips, thighs, buttocks (gluteal/femoral region), and breasts (Björntorp 1997). The distribution of body fat can be measured using the waist-to-hip ratio (WHR), which is calculated by dividing the circumference of the waist by the distance around the hips including the buttocks. A low WHR is correlated with earlier onset of menarche in girls (Lassek and Gaulin 2007), and maintenance of regular menstrual cycles (Van Hooff et al. 2000) and ovulatory cycles in women (Moran et al. 1999). Women with low WHRs and large breasts have higher levels of circulating estrogen and progesterone (Jasienska et al. 2004), and these hormones, in turn, are associated with higher rates of conception (Lipson and Ellison 1996). In studies conducted in fertility clinics, women with lower WHRs had the greatest success rates in artificial insemination (Zaadstra et al. 1993) and in in-vitro fertilization programs (Wass et al. 1997). Women's WHRs increase as they age, possibly due to reduction in estrogen production (Kirschner and Samojlik 1991; Wells 2007).

Sexual selection, via mate choice, may have favored the evolution of a low WHR in women as a signal of sexual maturity, health, and fecundity (Singh 1993). Numerous questionnaire studies have found that, in industrialized societies, stimulus images of women with low WHRs (0.6–0.7) are most attractive to men (in China: Dixson, Dixson, Li and Anderson 2007a; Germany: Henss 2000; UK: Furnham et al. 1997, Poland: Rozmus-Wrzesinska and Pawlowski 2005; New Zealand and USA: Dixson et al. 2010a). However, there is some cross-cultural discordance in male preferences for female WHR. Matsigenka men in Peru rate higher WHRs (0.9) as most attractive in women (Yu and Shepard 1998). Men from Bakossiland in Cameroon select as most attractive a female WHR of 0.8 (Dixson 2007b), as do Shiwiar men of the Ecuadorian Amazon (Sugiyama 2004). Research among the Hadza hunter-gatherers of Tanzania has produced some important findings with regard WHR and female attractiveness. Initial studies, which employed front-posed female images as stimuli, showed that men preferred a WHR of 0.9 (Wetsman and Marlowe 1999). However, in a follow-up study that used stimulus images in profile view so the buttocks were visible, Hadza men preferred a female WHR of 0.6 (Marlowe et al. 2005). The study by Marlowe et al. (2005) highlights an important methodological issue in research on female physique and sexual attractiveness. Studies of male preference for female WHR most often use stimuli in which images of women are presented in frontal view only. It is important to consider that WHR is calculated by measuring not only the circumference of the body at the waist and hips, but also the buttocks. Therefore men's attractiveness judgments may be affected by the body pose of the female stimulus images because they judge the waist region relative to the buttocks and breasts.

Eye-tracking techniques can provide data on attention to morphological traits when participants are making attractiveness judgments. Infants look longer at the faces of attractive adults (Langlois et al. 1987). In adults, eye-tracking research has shown that men look more often and longer at the faces of attractive women relative to faces they judge to be less attractive (Fink et al. 2008; Maner et al. 2008) and at the female body when viewing both erotic and non-erotic heterosexual scenes (Lykins et al. 2006, 2008; Rupp and Wallen 2007). When viewing clothed full-body images, men initially fixate on women's faces, followed by long fixations on the breasts (Hewig et al. 2008). Similarly, the breasts in particular are the focus of attention when men are asked to judge the attractiveness of front-posed images of women wearing dresses, bathing suits, and flesh-colored underwear (Cornelissen et al. 2009; Suschinsky et al. 2007). In a recent eye-tracking study, in which men looked at nude full-length images of women that had been altered to show small, medium, or large breasts, and a WHR of either 0.7 or 0.9, male attention was directed most often at the breasts. Initial visual fixations, occurring during the first 200 milliseconds of an eye-tracking session, most often involved either the female midriff or the breasts (Dixson et al. 2009).

These eye-tracking studies have consistently shown that female breasts capture male attention when the men are asked to make judgments of female physical attractiveness. However, the few studies conducted to date have presented participants with frontal images only. Male visual attention may show significant differences when viewing back-posed female images because the lower body and buttocks are displayed prominently rather than the breasts. As such, we hypothesize that the female midriff region will receive greater visual attention from men when images are presented in back view as compared with frontal views, but that low WHRs should still be judged as most attractive. To test this, men were presented with three front-posed images varying in WHR (0.7, 0.8, and 0.9). Back-view images of the same woman were presented showing the same range of WHRs. We measured the initial fixation, number of fixations, and dwell times for six body regions during 5 s eye-tracking sessions. Men also rated the six images for sexual attractiveness.

## Method

### Participants

Thirty heterosexual men of European descent, ranging in age from 25 to 44 years ($M$= 28.67 years, SD=4.82), 10 of whom were married, were recruited opportunistically from the staff and postgraduate student body at Victoria University. Participants were given individual verbal orientation before the start of data collection and allowed some time to familiarize themselves with the room and the eye-tracking machine. The details of the study were not discussed with participants beforehand. However, when each participant had completed the experiments, they were provided with written details of the rationale for the research. Each participant was told of their right to withdraw from the study without prejudice. All participants had normal vision or correction by contact

lenses. None wore glasses. The project was pre-approved by the Human Ethics Committee of the School of Psychology at Victoria University.

## Apparatus and Materials

A color photograph of a naked woman (Simblet 2001), taken from front and back, was scanned. WHR was manipulated using Photoshop Version 7.0 by narrowing or widening the waist to construct three levels of WHR (0.7, 0.8, and 0.9) for the image in front and in back views. Thus, six images were created. The experiment was programmed using SR Research Experiment Builder (version 1.4.128 RC) and conducted on a 3-GHz Pentium D computer. Stimuli were presented on a 21-inch monitor at a resolution of 1024×768 pixels and with a refresh rate of 60 Hz.

## Procedure

Participants were seated in a comfortable chair in a quiet room facing the monitor at eye level at a viewing distance of 57 cm, maintained by forehead and chin rests. They underwent eye-tracking trials in which each image was presented individually, in random order, on the computer screen for 5 s.

### *Attractiveness Measurement*

At the end of each presentation, participants were instructed to rate the image for attractiveness using a keyboard with a six-point Likert scale (1=unattractive, 2=slightly attractive, 3=moderately attractive, 4=attractive, 5=very attractive, and 6=extremely attractive).

### *Eye Tracking*

Using the EyeLink® 1000 Tower Mount Head Supported System (SR Research Ltd., Ontario, Canada), eye position and eye movements were determined by measuring the corneal reflection and dark pupil with a video-based infrared camera and an infrared reflective mirror. The eye tracker had a spatial resolution of 0.01° of visual angle and the signal was sampled and stored at a rate of 1000 Hz. Although viewing was binocular, recording was monocular, measuring right-eye movements only—a standard procedure in eye-tracking studies (e.g. Lykins et al. 2008). Calibration and validation of measurements were performed before each experimental session.

After the data were collected, the front-posed stimulus images were divided into six anatomical regions for subsequent analysis (Fig. 1): (1) the face and neck, from the top of the head to the level of the clavicle; (2) the breasts, from the top of the clavicle to the posterior border of each breast; (3) the midriff, including the waist, extending from the below the breasts to the widest part of the hips; (4) the pubic triangle, as defined by the limits of the pubic hair; (5) the thighs, the upper portion of the leg ending at the knee; and (6) the lower legs and feet. The arms were not included in the analyses because they received very little visual attention as follows: visual attention. The back-posed images were also divided into six anatomical regions, defined as follows: (1) the head and neck, from the top of the head to the

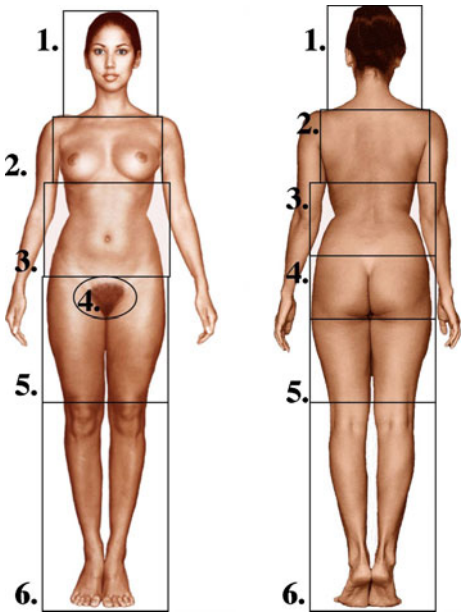


**Fig. 1** Female images were divided into six anatomical regions in order to analyze male visual attention during eye tracking. See text for definitions

base of the neck; (2) the back, from the bottom of the neck to the waist; (3) the midriff, including the waist, extending from the waist to the widest part of the hips; (4) the buttocks, from the bottom of the waist to below the buttocks; (5) the thighs, the upper portion of the leg ending at the knee; and (6) the lower legs and feet.

In each of the six regions, three dependent variables of eye movement were measured: first fixation, number of fixations, and amount of time spent (dwell time) examining the area. The first region of the body that was examined, at 200 milliseconds after the start of the test, was defined as the first fixation. The lag time of 200 milliseconds was allowed in order to give sufficient time for the eye to move from its initial fixation point in the center of the screen. Each time the eye moved, the eye-tracker recorded a new fixation. The number and duration of fixations made on each of the six regions were summed during the analysis.

## Results

### Attractiveness

A 2 (body pose: front, back)×3 (WHR: 0.7, 0.8, 0.9) repeated measures ANOVA yielded a significant main effect for WHR on attractiveness ratings ($F_{2,\ 58}$=36.01, $p$< 0.001, $\eta_p^2$=0.554). Images with 0.7 WHRs were significantly more attractive than images with 0.8 WHRs ($t$=2.90, df=29, $p$=0.007) and 0.9 WHRs ($t$=7.02, df=29, $p$< 0.001). Images with 0.8 WHRs were significantly more attractive than images with 0.9 WHRs ($t$=6.10, df=29, $p$<0.001) (Fig. 2). The effect of body pose approached significance ($F_{1,\ 29}$=4.08, $p$=0.053, $\eta_p^2$=0.123), which reflects a trend toward images in front view ($M$=3.71, SD=0.60) being judged as more attractive than images in back

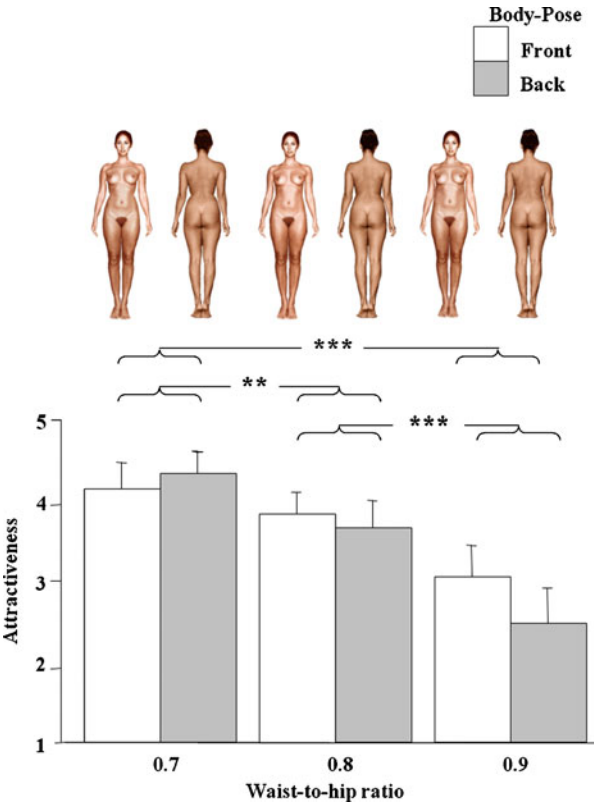


**Fig. 2** Mean ratings (+SD) for sexual attractiveness of six female images varying in WHR and body pose. ** $p<0.01$, *** $p<0.001$

view ($M=3.49$, SD=0.74). There was also a significant body pose×WHR interaction ($F_{2,\ 58}=7.74$, $p<0.001$, $\eta_p^2=0.211$), a result of the front-posed 0.9 WHR image receiving significantly higher ratings of attractiveness than the back-posed 0.9 WHR image ($t=3.52$, df=29, $p<0.001$).

## Eye Tracking

### *First Fixation*

For the frontal images, the breasts received the highest number of first fixations on the image with a 0.7 WHR. The midriff received the highest number of first fixations on the image with a 0.8 WHR. For the 0.9 WHR frontal image, the breasts and midriff received the majority of men's first fixations. When men looked at back-posed images, the midriff received more first fixations irrespective of WHR (Table 1).

### *Number of Fixations*

For number of fixations a 2 (body pose)×3 (WHR)×6 (body region)×5 (time: seconds 1–5) repeated measures ANOVA yielded a significant main effect of time

**Table 1** Number (and %) of men ($N$=30) who fixed their eyes first on one of five body regions. Data are shown for all six female images (3 front, 3 back)

| WHR | Head | Breasts | Midriff | Pubis | Thighs |
|---|---|---|---|---|---|
| Front | | | | | |
| 0.7 | 5 (16.6%) | 14 (46.6%) | 7 (23.3%) | 3 (10.0%) | 1 (3.3%) |
| 0.8 | 0 (0.0%) | 7 (23.3%) | 18 (60.0%) | 2 (6.6%) | 3 (10.0%) |
| 0.9 | 2 (6.6%) | 12 (40.0%) | 13 (43.3%) | 2 (6.6%) | 1 (3.3%) |
| Back | | | | | |
| 0.7 | 3 (10.0%) | 7 (23.3%) | 13 (43.3%) | 7 (23.3%) | 0 (0.0%) |
| 0.8 | 1 (3.3%) | 7 (23.3%) | 16 (53.3%) | 6 (20.0%) | 0 (0.0%) |
| 0.9 | 0 (0.0%) | 5 (16.6%) | 15 (50.0%) | 10 (33.3%) | 0 (0.0%) |

($F_{4,\ 116}$=49.78, $p$<0.001, $\eta_p^2$=0.632), body region and time ($F_{20,\ 580}$=6.75, $p$<0.001, $\eta_p^2$=0.189), and a significant three-way interaction between WHR, body region, and time ($F_{40,\ 1160}$=1.92, $p$<0.001, $\eta_p^2$=0.062). These interactions indicate that men fixated more often on the midriff of images with 0.8 ($M$=1.33, SE=0.11) and 0.9 ($M$=1.18, SE=0.11) WHRs than with 0.7 WHRs ($M$=0.67, SE=0.10) during the first second of eye tracking. There were no interactions between time and body pose ($F_{4,\ 116}$=0.67, $p$=0.614, $\eta_p^2$=0.023); time and WHR ($F_{8,\ 232}$=1.43, $p$=0.183, $\eta_p^2$=0.047); body pose, WHR, and time ($F_{8,\ 232}$=0.487, $p$=0.865, $\eta_p^2$=0.017); or body pose, body region, and time ($F_{20,\ 580}$=1.55, $p$=0.059, $\eta_p^2$=0.051).

The ANOVA also yielded a significant body pose×body region interaction ($F_{5,\ 145}$=65.49, $p$<0.001, $\eta_p^2$=0.693), and a WHR×body region interaction ($F_{10,\ 290}$=6.25, $p$<0.001, $\eta_p^2$=0.177). These two-way interactions were qualified by a three-way interaction between body pose, body region, and WHR ($F_{10,\ 290}$=4.05, $p$<0.001, $\eta_p^2$=0.123). Men directed more fixations toward the upper body (head, breasts, and midriff) than the lower body (pubis, thighs, and lower legs) when viewing frontal images. For back-posed images, the buttocks and midriff received more fixations (Table 2).

**Table 2** Mean numbers of visual fixations ± standard deviations for each of the six body regions over the five seconds of the eye-tracking experiments. Data are shown for all six female images (3 front, 3 back)

| WHR | Head | Breasts | Midriff | Pubis | Thighs | Legs/Feet |
|---|---|---|---|---|---|---|
| Front | | | | | | |
| 0.7 | 3.63±2.68 | 4.80±2.34 | 2.43±1.48 | 1.73±1.41 | 1.60±1.54 | 0.97±1.03 |
| 0.8 | 3.37±2.27 | 5.57±2.40 | 3.23±1.85 | 2.07±1.44 | 1.73±1.53 | 0.53±1.07 |
| 0.9 | 2.13±1.19 | 4.63±2.37 | 4.80±2.12 | 2.20±1.27 | 1.43±1.57 | 0.40±0.85 |
| Back | | | | | | |
| 0.7 | 1.17±1.70 | 2.07±1.28 | 3.77±1.75 | 4.80±1.51 | 0.87±0.82 | 0.90±1.21 |
| 0.8 | 0.83±1.02 | 1.97±1.45 | 5.40±2.01 | 4.83±1.84 | 0.43±0.68 | 0.37±0.67 |
| 0.9 | 0.87±1.04 | 1.67±1.18 | 4.70±2.56 | 4.53±1.70 | 0.70±0.79 | 1.07±1.39 |

As represented in Fig. 3, the interactions between body pose, body region, and WHR revealed in the ANOVA reflect that men viewing frontal images with 0.7 and 0.8 WHRs looked more often at the breasts than the waist. However, when looking at frontal images with a 0.9 WHR, men spent as much time looking at the midriff as the breasts. Similarly, when viewing back-posed images, number of fixations on the midriff increased as men viewed images with higher WHRs.

### *Dwell Times*

For dwell times, a 2 (body pose)×3 (WHR)×6 (body region)×5 (time: seconds 1–5) repeated measures ANOVA yielded a significant main effect of time ($F_{4,\ 116}=13.14$, $p<0.001$, $\eta_p^2=0.312$), time and WHR ($F_{8,\ 232}=2.16$, $p=0.032$, $\eta_p^2=0.069$), and time and body region ($F_{20,\ 580}=1.67$, $p=0.033$, $\eta_p^2=0.055$). There was also a trend toward a three-way interaction between time, body region, and WHR ($F_{40,\ 1160}=1.37$, $p=0.064$, $\eta_p^2=0.045$). These interactions reflect that men looked longer at the midriff in images with WHRs of 0.8 ($M=349.90$, SE=30.17) and 0.9 ($M=337.68$, SE=36.34) than 0.7 ($M=186.27$, SE=33.70) during the first second of eye tracking. There were

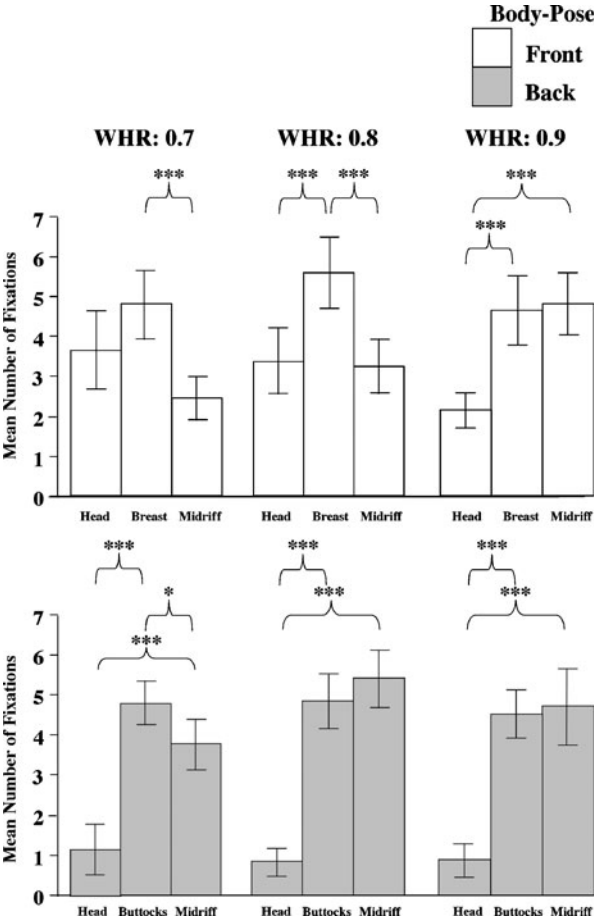


**Fig. 3** Mean numbers of fixations (+SD) made on the head, breasts, and midriff of front-posed images (*upper histograms*) and the head, buttocks, and midriff of back-posed images (*lower histograms*). Symbols indicate the level of statistical significance from paired *t*-tests between the different body regions. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

no significant interactions between time and body pose ($F_{4, 116}$=0.648, $p$=0.630, $\eta_p^2$= 0.022), or three-way interactions between body pose, WHR, and time ($F_{8, 232}$=1.44, $p$=0.182, $\eta_p^2$=0.047) or body pose, body region, and time ($F_{20,580}$=0.672, $p$=0.855, $\eta_p^2$=0.023).

For dwell times the ANOVA also yielded a significant body pose×body region interaction ($F_{5, 145}$=56.75, $p$<0.001, $\eta_p^2$=0.662), and a WHR×body region interaction ($F_{10,290}$=4.36, $p$<0.001, $\eta_p^2$=0.131). These two-way interactions were qualified by a three-way interaction between body pose, body region, and WHR ($F_{10, 290}$=2.48, $p$=0.007, $\eta_p^2$=0.079). When viewing frontal images, men's visual attention was directed more to the upper body (head, breasts, and midriff) than the lower body (pubis, thighs, and lower legs). When looking at back-posed images, men's attention was most often toward the midriff and buttocks (Table 3).

As can be seen in Fig. 4, the interactions between body pose, body region, and WHR revealed in the ANOVA reflect that when men were looking at frontal images with 0.7 and 0.8 WHRs, they look at the breasts significantly longer than the head and midriff. However, when front-posed images with 0.9 WHRs were examined, men spent as much time looking at the breasts as the midriff. When looking at back-posed images, men looked at the buttocks and midriff longer than the head, irrespective of WHR.

## Discussion

This study quantified eye movements of men during attractiveness judgments of front- and back-posed images of women varying in waist-to-hip ratio (WHR). Images with 0.7 WHRs were rated as most attractive, irrespective of body pose. The initial fixation, occurring 200 milliseconds from the start of the eye-tracking experiment, most frequently involved the breasts for frontal images with a 0.7 WHR and the midriff for 0.8 WHR, whereas for 0.9 WHR the first fixations fell most often on the breasts and midriff. For images in back view, the midriff received the most first fixations for all WHRs. Over the full 5 s of the eye-tracking trials, men paid more attention to the midriff of images with 0.9 WHRs than images with 0.7 or 0.8 WHRs.

Previous eye-tracking studies, which have employed different methods to quantify attention on female WHRs, did not reveal a relationship between eye movements toward the midriff and judgments of female attractiveness. Suschinsky et al. (2007) showed men three images (simultaneously) of the same clothed woman, computer-morphed to differ in WHR, and asked them to select the image they found most attractive. Although men looked at the image with the lowest WHR more often and for longer than images with higher WHRs, and selected it as most attractive, relatively little attention was given to the midriff region. Cornelissen et al. (2009) presented men and women with images of individual women wearing flesh-colored vests and briefs and asked one group of participants to rate them for WHR, a second group to rate them for total body fat, and a third group to rate them for attractiveness. Eye movements when making attractiveness judgments were correlated with judgments of total body fat but not WHR, suggesting that the WHR region is not of importance when assessing female physical attractiveness. Finally, Dixson et al.

**Table 3** Mean dwell times ± standard deviations for each of the six body regions over the 5 s of the eye-tracking experiments. Data are shown for all six female images (3 front, 3 back)

| WHR | Head | Breasts | Midriff | Pubis | Thighs | Legs/Feet |
|---|---|---|---|---|---|---|
| Front | | | | | | |
| 0.7 | 952.30±737.38 | 1477.70±725.58 | 923.20±634.16 | 486.13±500.65 | 537.03±576.55 | 376.70±374.13 |
| 0.8 | 961.53±739.39 | 1691.73±768.78 | 1118.53±628.00 | 386.20±372.97 | 460.60±431.89 | 172.63±356.79 |
| 0.9 | 556.23±313.48 | 1530.57±739.40 | 1610.00±774.67 | 528.57±452.04 | 397.93±413.33 | 124.23±263.13 |
| Back | | | | | | |
| 0.7 | 381.20±502.86 | 665.47±380.50 | 1475.57±682.22 | 1502.57±523.08 | 349.37±345.17 | 342.27±445.89 |
| 0.8 | 288.90±347.88 | 677.33±471.54 | 1936.17±720.10 | 1548.57±675.04 | 187.43±364.43 | 124.50±216.66 |
| 0.9 | 247.40±323.17 | 699.10±553.12 | 1776.90±948.63 | 1407.17±732.09 | 273.23±365.45 | 344.20±444.68 |

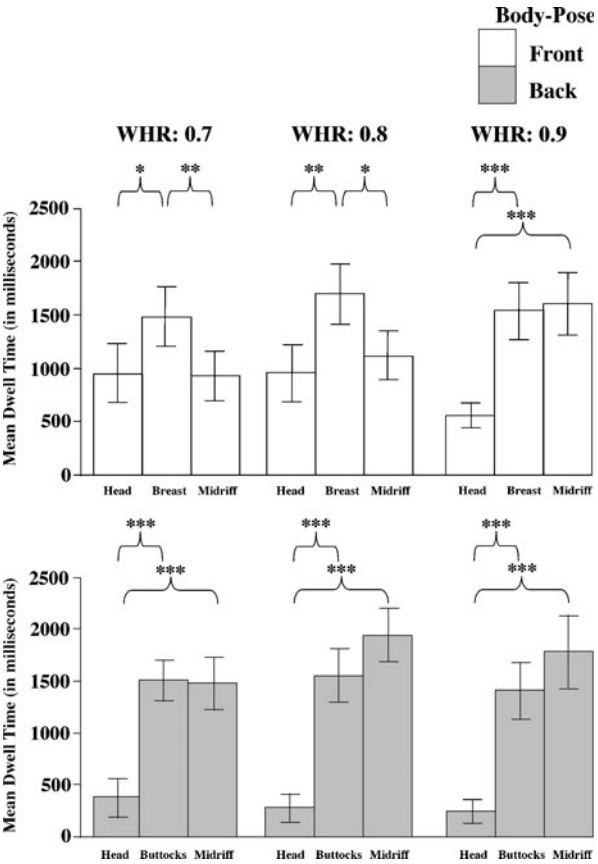


**Fig. 4** Mean dwell times (+SD) made on the head, breasts, and midriff of front-posed images (*upper histograms*) and the head, buttocks, and midriff of back posed images (*lower histograms*). Symbols indicate the level of statistical significance from paired *t*-tests between the different body regions. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

(2009) showed that although WHR was the primary determinant of male attractiveness ratings when judging full-length nude images, the midriff was not the main focus of their attention when they made attractiveness judgments. These studies indicate that there is discordance between male attention for traits that define female body shape and their subjective attractiveness ratings.

Attractiveness judgments involve complex processes in which a constellation of traits likely influences perceptions of physical beauty. The results of the current study suggest that in the case of female attractiveness and WHR, the midriff is, in fact, an important region that appears to be judged in relation to surrounding features, such as the breasts and buttocks. In keeping with previous eye-tracking studies, the breasts were shown to capture the most male attention, particularly when the WHR is judged as more attractive. When the WHR is higher, male attention returns more frequently and remains for longer on the midriff than when looking at images with narrower waists. This suggests that men actively attend to those regions where female fat accumulation is greatest and achieve an appreciation of the "hourglass shape." This process may occur very rapidly since men began to analyze the midriff within the first 200 ms of viewing. After this initial fixation the midriff is only a more salient feature of attentional capture, relative to the head and breasts, if the WHR is higher. Singh (1993) hypothesized that female WHR represents a "first-

pass filter" in male judgments of female attractiveness. Under this hypothesis, the WHR region is judged prior to other traits because it represents an unambiguous signal of female gender, health, fertility, and attractiveness (Singh 1993). The findings of the current study provide further support for Singh's hypothesis since men ultimately rated images with a low WHR of 0.7 as most attractive. Interestingly, when the WHR is rated more attractive, men are less reliant on the waist area to guide their behavioral and subjective judgments of female physical attractiveness than when viewing images with less-attractive WHRs.

It is important to note that eye movements are not implicit measures of perceived attractiveness. They are an index of attention, and visual attention depends very much on the motivation of the individual. For example, stimuli that are associated with fear and reward have been shown to capture attention (Castellanos et al. 2009; De Martino et al. 2009; Raymond and O'Brien 2009). In such circumstances attentional capture may be an active or endogenous process by which participants control how they allocate attention in order to achieve a goal (Ruz and Lupiáñez 2002). Alternatively, attention may be passive or exogenous, whereby participants allocate their attention to stimuli without intention (Ruz and Lupiáñez 2002). There is some evidence that physical attractiveness actively captures attention. Shimojo et al. (2003) found that when the more attractive face was being identified among pairs of faces, participants' gazes were initially shared evenly between faces. However, as the experiment progressed, gazes were biased toward the face ultimately judged to be more attractive. Maner et al. (2007) found that attentional bias toward attractive female faces occurred within the first second of a visual cueing experiment and that participants showed reluctance to disengage from more-attractive faces. However, the conclusion that attractiveness is the primary motivation for such attentional capture may not be entirely accurate since novel, unique, attractive and unattractive traits have been shown to capture attention in eye-tracking studies (Sütterlin et al. 2008). In the current study, it is possible that the greater attention given to the midriff of the image depicting a 0.9 WHR was due to the use of computer-generated stimuli that resulted in a physical appearance that was visually novel. Thus, attentional capture of the midriff for less-attractive images may be an exogenous passive response to a novel or unique trait rather than an endogenous mechanism whereby participants are processing the features that make up an attractive female physique.

The use of computer-morphing to experimentally manipulate WHR may indeed be problematic as such techniques also alter the body mass index (BMI; Tovée and Cornelissen 2001). BMI is calculated as weight in kilograms divided by (height in meters)$^2$. In a series of cross-cultural studies, differences in women's BMI were found to exert a greater influence than WHR on male ratings of female attractiveness in Japan (Swami et al. 2006), Malaysia (Swami and Tovée 2005), and Zululand in South Africa (Tovée et al. 2006). These authors question the validity of the WHR hypothesis based on the findings in these studies. However, WHR and BMI are positively correlated, and as such it is very difficult to test the individual contribution made by each of these traits to men's judgments of female attractiveness. A recently developed procedure called micrograft surgery may provide such an opportunity; in this procedure, adipose tissue is harvested from the waist and used to reshape the buttocks of female patients, which reduces WHR without altering BMI (Singh and

Randall 2007). It has been shown that men in a wide variety of cultures select postoperative images of these women as most attractive (Dixson, Li and Dixson 2010b, Dixson, Sagata et al. 2010c; Singh et al. 2010). Recently, Platek and Singh (2010) used fMRI scanning to measure men's neurological responses to images of women who had undergone micrograft surgery. They found that the right and left orbital frontal cortex showed activation and that such activation was significantly greater when viewing postoperative, as compared with preoperative, images. This research shows that responses to WHR are measurable at a central level in an area of the brain that is concerned with reward.

The application of eye-tracking technology in studies of sexual selection and the evolution of human physical attractiveness is relatively new. The current study confirms the importance of female WHR in male judgments of attractiveness and provides preliminary evidence that men's behavioral responses are mediated, in part, by WHR. The use of images that varied in body pose was an important addition to previous eye-tracking studies because it enabled analyses of attention to the WHR region when features known to capture attention (i.e., the face and breasts) were not visible. Eye tracking may provide a key behavioral link in evolutionary studies of sexual selection and morphology. However, uncovering to what extent attractiveness judgments, attentional capture, and morphology are interrelated is a complex challenge for researchers. Future research may seek to uncover whether an attractiveness judgment actively relates to morphology through the use of paired stimuli presented for comparison. A further question involves how women might respond to images that vary in WHR, perhaps as a consequence of intrasexual mate competition. What is clear from this research is that the combination of psychological methods and evolutionary biology may yield significant advances in our knowledge of what constitutes physical attractiveness.

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