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ORIGINAL PAPER

Waist-to-Hip Ratio as Supernormal Stimuli: Effect of Contrapposto Pose and Viewing Angle

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Abstract

In women, the waist-to-hip ratio (WHR) is an indicator of attractiveness, health, youthfulness, and reproductive potential. In the current study, we hypothesized that viewing angle and body postures influence the attractiveness of these forms based on the view dependency of WHR stimuli (vdWHR). Using eye tracking, we quantified the number of fixations and dwell time on 3D images of a female avatar in two different poses (standing and contrapposto) from eight viewing angles incrementing in 45 degrees of rotation. A total of 68 heterosexual individuals (25 men and 43 women) participated in the study. Results showed that the contrapposto pose was perceived as more attractive than the standing pose and that lower vdWHR sides of the stimuli attracted more first fixation, total fixations, and dwell time. Overall, the results supported that WHR is view-dependent and vdWHRs lower than optimal WHRs are supernormal stimuli that may generate peak shifts in responding. Results are discussed in terms of the attractiveness of women's movements (gaits and dance) and augmented artistic presentations.

Keywords Supernormal stimuli · Waist-to-hip ratio · Peak shift effect · Physical attractiveness

Introduction

In a classic paper, Singh (1993a) introduced the role of women's waist-to-hip ratio (WHR) into the attractiveness literature and evolutionary psychology by providing links between female youthfulness, health, reproductive potential, and physical attractiveness. Further studies confirmed the effect of WHR on attractiveness across gender and ethnicity (Furnham, Tan, & McManus, 1997; Henss, 1995; Singh, 1993b; Singh & Luis, 1995). Although many results confirm that the preferred ratio of .70 is consistent across cultures (Furnham, McClelland, & Omer, 2003; Singh, Dixson, Jessop, Morgan, & Dixson, 2010), other disconfirmatory results have been obtained from non-Western populations that report preferences for WHRs that are either slightly higher (e.g., .80 in Cameroon) or lower (e.g., .60 in China) (Dixson, Dixson, Li, & Anderson, 2007a; Dixson, Dixson, Morgan, & Anderson, 2007b).

It has been suggested that preference variations are ecology-dependent such that resource scarcity leads to a preference for higher WHRs (Marlowe & Wetsman, 2001; Yu & Shepard, 1998) and that higher than .70 WHRs are adaptive in stressful environments where women make more competitive trade-offs (Cashdan, 2008) even while physiological studies have demonstrated a link between women's WHR and fertility. For example, it was shown that a low WHR was associated with high in vivo (Zaadstra et al., 1993) and in vitro (Wass, Waldenström, Rössner, & Hellberg, 1997) fertility rates. Moreover, there is a positive association between high WHR and anovulation rates (Morán et al., 1999) and a negative association between high WHR and mid-cycle levels of estradiol (Jasieńska, Ziomkiewicz, Ellison, Lipson, & Thune, 2004, but see Grillot, Simmons, Lukaszewski, & Roney, 2014 for no relationship). While preferred WHR shows some variation across cultures (Marlowe, Apicella, & Reed, 2005) and time (Bovet & Raymond, 2015), research has shown that WHR plays an important role as a cue to women's physical attractiveness (Tovée & Cornelissen, 1999).

Additional research employing eye tracking has confirmed WHR effects on perceived attractiveness using digitally

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manipulated female nude photographs (Dixson, Grimshaw, Linklater, & Dixson, 2010; Dixson et al., 2011b), and the role of WHR has been broadened to include artistic portrayals of women in sculptures and paintings (Bovet & Raymond, 2015). Eye tracking has shown that breasts and waists receive the first, rapid eye fixations, followed by longer observations of adjoining areas, and that hourglass (.70) WHRs are rated as more attractive, in front and back views, than higher (e.g., .90) WHRs (Dixson et al., 2010; Dixson, Grimshaw, Linklater, & Dixson, 2011a). Furthermore, viewers look at the edges of torsos; specifically, in restricted gaze conditions, participants focus on the edges of breasts (front view) and hips (in front and back views), while in more natural conditions gazes cluster centrally to sternal and naval regions allowing assessment of both outer silhouette edges simultaneously (Bovet, Lao, Bartholomée, Caldara, & Raymond, 2016). When the WHRs of over 200 images of ancient to more recent sculptures and paintings of women in various poses (sitting, standing, lying) and orientations (face, back, and profile) were analyzed (Bovet & Raymond, 2015), the WHRs depicted ranged from ~.66 to ~.80 with a mean of ~.73–a range that includes, and centers on, healthy, attractive, and fecund women.

Contrapposto, Peak Shift, and Supernormal Stimuli

Contrapposto pose is frequently depicted in artist's paintings and sculptures. It refers to a position of a human body in which twisting along the vertical axis results in hips, shoulders, and head being turned in different directions as weight is borne by one or the other leg. There are ubiquitous examples of contrapposto pose in the arts since antiquity (e.g., Colonna Venus and Aphrodite of Knidos from the Classical period and Venus de Milo from the Hellenistic period) to the present day's photographs of models and actresses. Early WHR studies have used either contrapposto-like or standing body posture depictions of women (Henss, 1995; Singh, 1993a; Singh & Luis, 1995; Tovée & Cornelissen, 2001; Tovée, Maisey, Emery, & Cornelissen, 1999; Wetsman & Marlowe, 1999). However, it has been argued that studies using 2D images of bodies (Cornelissen, Hancock, Kiviniemi, George, & Tovée, 2009; Tovée, Hancock, Mahmoodi, Singleton, & Cornelissen, 2002) are not evaluating actual WHR (waist circumference divided by hip circumference). What is being evaluated can be termed "view-dependent waist-to-hip ratios" (vdWHRs) (Doyle, 2009a). VdWHR measures across the narrowest width of the waist and widest width at the hips. The actual WHR and vdWHRs of a given form may be the same from a specific viewpoint of a given posture, but they are only infrequently overlapping (Doyle, 2009b). VdWHRs can also be derived for each side of a figure by measuring outward from a medially placed centerline. Previous WHR research has not only confounded weight with hip size (Tassinary & Hansen, 1998), it has conflated WHR with vdWHR. Since actual WHR and vdWHR are not the same construct, they cannot be used interchangeably, whether in WHR manipulated photographs (Henss, 2000) or artistic guises (Swami, Grant, & Furnham, 2007). As demonstrations that changing poses and orientations show, vdWHR can vary widely even while WHR remains invariant.

Ramachandran and Hirstein (1999) suggested that artists exaggerate the female form and that these exaggerations are supernormal stimuli that may create peak shift effects in viewers. Further, Ramachandran (2004) postulated that unrealistic depictions, such as those made by cartoonists, seem to make use of the peak shift principle when making caricatures of people by amplifying their unique features. In a laboratory setting, Derenne, Breitstein, and Cicha (2008) examined the role of discrimination training in creating peak shift effects (Hanson, 1959) using WHR silhouettes. The stimuli ranged between .70 and .80 where .75 represented optimal and .80 represented the mean of heathy adult women. Conditions had either "small" (.07) or "large" (.80) sizes relative to the optimal for discrimination. Their procedure resulted in peak shifts away from the .75 optimum, confirming that peak shifts are possible from WHR-related stimuli. The effect has also been sought from naturally behaving stimuli in more ecologically valid scenarios (Doyle, 2009a, 2010a). Arguably, bodily pose and orientation influence perceptions of attractiveness by alternating vdWHRs and these dynamic arrays generate peak shift effects in observers. Furthermore, peak-shifting viewpoint-dependent WHRs may be within a lower range than the preferred optimally attractive actual ratio (i.e., 0.7) and thus might be considered what ethologists term "supernormal stimuli."

It has also been suggested that cartoon art, video games, and animated characters such as Jessica Rabbit, Lara Croft, and Betty Boop contain supernormal stimuli by virtue of their supernormally low vdWHRs and the augmented topline contours of their breasts (Doyle, 2010b). This latter claim stems from Marlowe's (1998) nubility hypothesis which states that women's protruding breasts are honest signals of age and residual reproductive value and was supported in cross-cultural (i.e., English- and Farsi-speaking) samples using computer-generated images of breasts of differing sizes and shapes, including those depicting unnatural firmness (Doyle & Pazhoohi, 2012). Attractiveness ratings for both natural and augmented breasts increased with cup size, and breast area ("largeness") but supernormally firm breasts with toplines displaced upward (convex contours) were preferred regardless of cup size or area. This claim was further supported in studies with participants from Brazil, Cameroon, Namibia, and the Czech Republic where participants favored images depicting firmer shapes and sizes within natural ranges (Havlíček et al., 2016) and accords with previous findings that there are preferences for medium and large breast sizes in New Zealand, Samoa, and Papua New Guinea (Dixson et al., 2011b) as well as a linear relationship between size and attractiveness for naturalistic breast images (Dixson, Duncan, & Dixson, 2015). One interpretation of the findings from the supernormal breast study is that unnaturally non-ptotic breast depictions and augmentations are deceptive signals of residual reproductive value. The former suggestion finds support in the finding that, in a sample of images of imaginary women selected by university students for attractiveness, very low vdWHRs (reported as predicted WHR) ranging from .39 to .64 predominated (Lassek & Gaulin, 2016). Recent evidence also strongly suggests that supernormal stimuli capable of producing peak shift effects are preferred to average female characteristics. Marković and Bulut (2017) created sets of computer images of women's breasts, buttocks, and WHRs in front, side, and posterior views with six levels of femininity and asked one group of participants to rate whole body images and another to rate isolated versions of the stimuli. In two separate tasks, participants were asked to select the average and the most attractive. They found that in both whole body and isolated contexts, more feminine "supernormal" levels of stimuli (smaller WHR, larger breasts, and larger buttocks) were found to be more attractive, by males and females, than average ones.

Current Study

The aim of the current study was to investigate the effect of these lower vdWHR on perceived attractiveness. Specifically, we hypothesized that: (1) women in contrapposto pose would be perceived as more attractive than in naturally standing pose; and (2) lower view-dependent WHR sides of women's midriffs would attract more attention than higher view-dependent WHR sides. To investigate this, we used eye tracking to monitor participants' gaze while looking at images of a 3D modeled woman in two different poses (standing and contrapposto) from eight viewing angles incrementing in 45 degrees of rotation. This allowed the WHR of the model to remain constant while allowing viewing angle to determine vdWHR, thus removing the possibility for confounds caused by using a number of different models with differing WHRs and BMIs or those caused by independently augmenting the widths of the waist and hips. Additionally, each participant provided ratings of attractiveness for each of the images. Eye tracking is considered a robust method to study human physical attractiveness and provides a behavioral link between evolutionary studies of sexual selection and morphology (Dixson et al., 2010; Wenzlaff, Briken, & Dekker, 2016).

Method

Participants

A total of 68 heterosexual individuals (25 males and 43 females) were recruited from undergraduate and graduate students at the University of Minho. Their mean age was 23.2 years ($SD = 5.57$). Undergraduate students received course credit in return for their participation. All participants had normal or corrected-to-normal vision. They all provided written informed consent. The experiment was approved by the ethical committee of University of Minho and was conducted in accordance with their guidelines.

Stimuli

A 3D female model was created using Daz3D software (http://www.daz3d.com) for the standing and contrapposto pose stimuli. The model was rotated around a vertical axis in 45 degree increments, yielding eight stimuli for each pose and 16 in total. All of the stimuli were cropped from clavicle to knee (Fig. 1). For each stimulus, the vdWHR was measured from the narrowest section of the waist and widest section of the hips to obtain view-dependent across-WHRs. Additionally, left and right vdWHRs for each stimulus were measured from a mid-line placed on the stimulus (see Table 1 for measured vdWHRs).

Procedure

Eye movements were monitored using a binocular infrared, remote eye tracker running at 250 Hz (RED250, SMI GmbH Germany) controlled with iView X software (v2.8). Stimuli were presented on a 22-inch LCD monitor (Dell P2210, 60 Hz, 1680 × 1050 pixels). Participants first completed a 5-point calibration procedure. Calibration was accepted if the mean spatial shift for four validation points was 0.5 degrees of visual angle or less for vertical and horizontal deviations. The experiment was carried out in a dim light room (~ 10 lx). Participants were seated, head free, at 70 cm from the monitor. The stimulus presentation was randomized using the Experimenter Center package (v. 3.6, SMI GmbH Germany), and each image was exposed to participants for 5 s. After viewing the stimuli, participants provided ratings for attractiveness on a 10-point Likert scale. To ensure that participants' attention was focused on the center of the screen before the onset of each stimulus presentation, a gaze-contingent fixation cross-appeared on the center of the computer screen (dwell time required 500 ms). After viewing all the stimuli, participants were debriefed and dismissed.

Data analysis was performed using the BGaze software (v3.6, SMI GmbH Germany). Saccades were separated from fixations using a peak-velocity threshold of 40 deg/s implemented in the BGaze package, based on the method defined by Smeets and Hooge (2003). Fixations with duration below 50 ms were discarded. Dwell time was defined as the sum of the duration of all fixations and saccades that hit the region of interest.

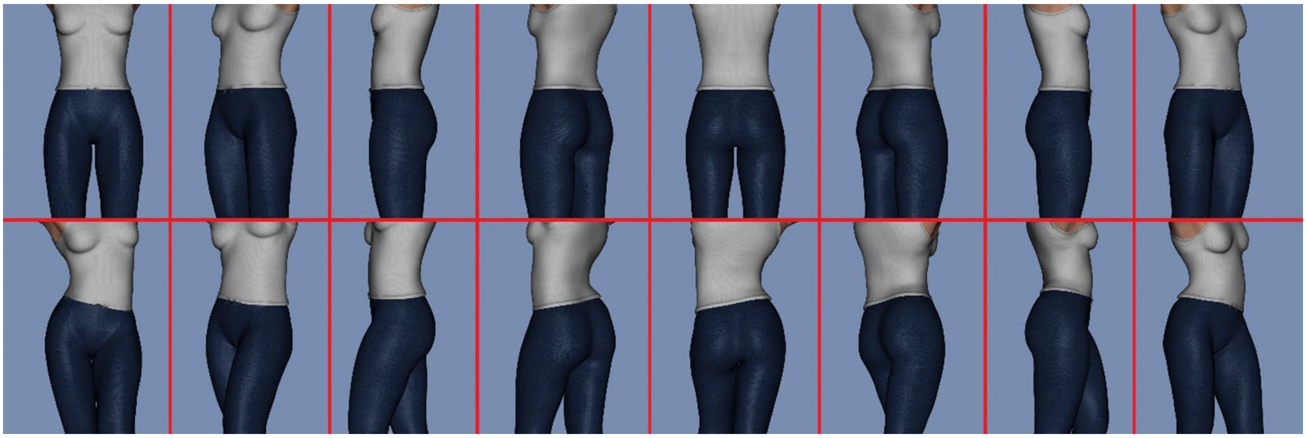

Fig. 1 Standing (upper row) and contrapposto (lower row) pose stimuli showing 360 degrees of *y* axis rotation

Table 1 Measures for across, left, and right view-dependent WHR for standing and contrapposto stimuli

	Standing			Contrapposto		
	Across-WHR	Left-WHR	Right-WHR	Across-WHR	Left-WHR	Right-WHR
0° (frontal)	0.66	0.66	0.66	0.67	0.51	0.84
45° (front profile)	0.67	0.67	0.65	0.72	0.64	0.83
90° (side)	0.77	1.06	0.58	0.75	1.14	0.60
135° (back profile)	0.67	0.67	0.65	0.66	0.82	0.53
180° (posterior)	0.66	0.66	0.66	0.67	0.84	0.51
225° (back profile)	0.67	0.65	0.67	0.72	0.83	0.64
270° (side)	0.77	0.58	1.06	0.75	0.60	1.14
315° (front profile)	0.67	0.65	0.67	0.66	0.53	0.82

Regions of Interest

Previous studies identified the midriff as the most important region in judging women's attractiveness (Cornelissen et al., 2009; Dixson et al., 2010). For the aim of the current study, which was to identify vdWHR effects across standing and contrapposto poses, the stimuli in the midriff region were divided into left and right sides, hence two areas of interest. Each side started beneath the breasts and end of the rib cage including the waist and finished above the pubic area. This adjustment was made to avoid pubic area falling within either left or right sides, affecting and hijacking dwell and fixation numbers.

Results

Ratings of Attractiveness

Table 2 shows the mean attractiveness ratings as a function of body pose and viewing angle. For the attractiveness rating, a 2 (Sex of Rater) × 2 (Body Pose) × 8 (Angle) repeated measures analysis of variance (ANOVA) was performed, with Sex as between-subjects variables and Body Pose and Angle as within-subjects variables. The results showed a significant main effect for Sex (Table 3). Men ($M = 6.51$, $SEM = 0.31$) rated the stimuli as more attractive than women ($M = 4.82$, $SEM = .24$). Results also showed a significant main effect for Body Pose (Table 3). Participants rated contrapposto stimuli ($M = 6.01$, $SEM = .20$) more attractive than standing ones ($M = 5.33$, $SEM = .21$). The results also showed a significant main effect for Angle and an Angle × Sex interaction (Table 3). Results showed that men rated both the side views (90° and 270°) lower than other angles, $F(7, 392) = 2.10$, $p = .042$; however, there was no preference in ratings of different angles for women, $F(7, 680) = .86$, $p = .534$. Moreover, the Angle × Body Pose interaction was significant. *t* tests were conducted to compare standing and contrapposto poses for attractiveness ratings of each viewing angle. Ratings for attractiveness were higher for contrapposto pose than standing pose in five viewing angles (Table 2).

Eye Tracking

Dwell Time

Tables 4 and 5 show the mean dwell times as a function of body pose, viewing angle, and vdWHR for male and female

Table 2 Results comparing standing and contrapposto poses for attractiveness ratings of each viewing angle ($N=68$)

	Standing		Contrapposto		t	p
	M	SD	M	SD		
0° (frontal)	5.30	2.16	6.20	2.25	−3.57	.001
45° (front profile)	5.29	2.15	5.36	2.07	−0.37	.708
90° (side)	5.01	1.94	5.33	2.19	−1.89	.062
135° (back profile)	5.27	2.05	5.83	2.20	−2.95	.004
180° (posterior)	5.07	2.22	5.85	2.26	−3.54	.001
225° (back profile)	5.08	2.10	6.22	2.10	−5.57	.001
270° (side)	4.98	2.06	5.80	2.00	−5.45	.001
315° (front profile)	5.02	2.16	5.44	2.11	−1.89	.062

Table 3 Repeated-measures ANOVA testing the effect of participants' sex, body posture (standing and contrapposto), and eight viewing angles on ratings of attractiveness

Source of variation	df	F	p	Partial η^2
Sex	1, 66	18.32	< .001	.22
Pose	1, 66	29.64	< .001	.31
Angle	7, 462	3.78	.001	.05
Body Pose × Sex	1, 66	2.71	.104	.04
Angle × Sex	7, 462	2.87	.006	.04
Body Pose × Angle	7, 462	4.42	< .001	.06
Body Pose × Angle × Sex	7, 462	0.74	.634	.01

participants, respectively. For dwell time, a 2 (Sex of Rater) × 2 (Body Pose) × 2 (vdWHR: Low vs. High) × 8 (Angle) repeated measures ANOVA was performed, with Sex as a between-subjects variables and Body Pose, vdWHR, and Angle as within-subjects variables. The ANOVA revealed significant main effects for Sex, vdWHR, and Angle (Table 6). Men ($M=896.38$ ms, $SEM=56.44$) had longer dwell time than women ($M=674.48$ ms, $SEM=43.04$, $p=.003$). The main effects were superseded by significant Body Pose × Sex, Body Pose × vdWHR, vdWHR × Sex, Body Pose × Angle, and Angle × vdWHR interactions (Table 6). These two-way interactions were also superseded by significant Body Pose × vdWHR × Sex and Body Pose × Angle × vdWHR interactions, and they were also qualified by a significant four-way Body Pose × Angle × vdWHR × Sex interaction (Table 6). This interaction indicates that both men and women had longer dwell time on lower vdWHR than higher vdWHR of contrapposto stimuli in almost all the angles; however, such difference was not observed for standing stimuli (Tables 4, 5).

Fixation Number

Tables 7 and 8 show the mean fixation number as a function of body pose, viewing angle, and vdWHR for male and female participants, respectively. For fixation number, a 2 (Sex of Rater) × 2 (Body Pose) × 2 (vdWHR: Low vs. High) × 8 (Angle) repeated measures ANOVA was performed, with Sex as a between-subjects variables and Body Pose, vdWHR, and Angle as within-subjects variables. The ANOVA revealed significant main effects for Sex, vdWHR, and Angle (Table 9). Men (M = 3.08, SEM = 0.18) had higher fixation numbers than women ($M=2.40$, $SEM=0.13$, $p=.004$) on the stimuli. The

Table 4 Mean, SD, and post hoc comparison for dwell time (ms) for left and right sides of standing and contrapposto poses of different viewing angles for male participants

	Standing							Contrapposto						
	Left			Right				Left			Right			
	WHR	M	SD	WHR	M	SD	p	WHR	M	SD	WHR	M	SD	p
0° (frontal)	0.66	803.64	667.58	0.66	728.76	581.06	.713	0.51	1756.44	1231.96	0.84	416.32	633.49	.001
45° (front profile)	0.67	1048.46	638.47	0.65	510.54	572.76	.001	0.64	1433.89	974.73	0.83	369.76	409.12	.001
90° (side)	1.06	923.52	739.14	0.58	1066.69	858.82	.512	1.14	773.28	501.89	0.60	1121.90	849.67	.058
135° (back profile)	0.67	583.99	404.64	0.65	744.79	849.41	.402	0.82	530.55	513.31	0.53	1195.78	951.57	.001
180° (posterior)	0.66	744.79	849.41	0.66	870.44	631.07	.408	0.84	261.10	354.96	0.51	2211.64	1409.29	.001
225° (back profile)	0.65	667.53	530.06	0.67	1174.33	765.59	.001	0.83	402.39	525.67	0.64	1379.93	1124.16	.001
270° (side)	0.58	881.92	651.59	1.06	825.11	777.45	.784	0.60	995.18	784.08	1.14	860.14	707.94	.477
315° (front profile)	0.65	725.43	543.44	0.67	688.46	692.13	.840	0.53	987.50	846.49	0.82	698.08	1044.17	.212

Table 5 Mean, SD, and post hoc comparison for dwell time (milliseconds) for left and right sides of standing and contrapposto poses of different viewing angles for female participants

	Standing							Contrapposto						
	Left			Right				Left			Right			
	WHR	M	SD	WHR	M	SD	*p*	WHR	M	SD	WHR	M	SD	*p*
0° (frontal)	0.66	856.69	795.63	0.66	653.10	541.85	.192	0.51	1055.1	711.27	0.84	410.32	514.79	.001
45° (front profile)	0.67	879.14	629.66	0.65	348.00	408.85	.001	0.64	859.9	616.07	0.83	194.42	230.72	.001
90° (side)	1.06	837.46	612.94	0.58	851.42	764.37	.933	1.14	673.2	613.5	0.60	651.34	515.83	.875
135° (back profile)	0.67	466.62	565.59	0.65	678.04	573.35	.150	0.82	386.88	466.41	0.53	779.42	551.94	.008
180° (posterior)	0.66	771.80	562.65	0.66	616.34	541.32	.301	0.84	249.38	336.39	0.51	1359.5	872.19	.001
225° (back profile)	0.65	620.92	569.74	0.67	725.48	531.38	.372	0.83	303.99	451.2	0.64	772.9	543.32	.002
270° (side)	0.58	863.30	712.21	1.06	820.07	733.44	.784	0.60	815.7	592.65	1.14	474.69	487.14	.021
315° (front profile)	0.65	633.91	615.41	0.67	629.57	604.08	.975	0.53	777.46	546.27	0.82	567.35	705.34	.234

Table 6 Repeated-measures ANOVA testing the effect of participants' sex, body pose (standing and contrapposto), vdWHR (low vs. high), and eight viewing angles on dwell time

Source of variation	*df*	*F*	*p*	Partial η^2
Sex	1, 66	9.77	.003	.13
Body Pose	1, 66	1.92	.170	.03
vdWHR	1, 66	91.30	< .001	.58
Angle	7, 462	7.68	< .001	.10
Body Pose × Sex	1, 66	12.55	.001	.16
Body Pose × vdWHR	1, 66	119.45	< .001	.64
vdWHR × Sex	1, 66	5.14	.027	.07
Angle × Sex	7, 462	1.52	.158	.02
Body Pose × Angle	7, 462	3.41	.001	.05
Angle × vdWHR	7, 462	7.99	< .001	.11
Body Pose × vdWHR × Sex	1, 66	12.25	.001	.16
Body Pose × Angle × Sex	7, 462	0.46	.861	.01
Angle × Angle × Sex	7, 462	0.68	.690	.01
Body Pose × Angle × vdWHR	7, 462	10.89	< .001	.14
Body Pose × Angle × vdWHR × Sex	7, 462	2.83	.007	.04

main effects were superseded by significant Body Pose × Sex, Body Pose × vdWHR, Body Pose × Angle, and Angle × vdWHR interactions (Table 9). These two-way interactions were also superseded by a significant Body Pose × Angle × vdWHR interaction and were qualified by a significant four-way Body Pose × Angle × vdWHR × Sex interaction (Table 9). This interaction indicates that both men and women had longer dwell time on lower vdWHR than higher vdWHR of contrapposto stimuli in almost all the angles; however, such difference was not observed for standing stimuli (Tables 7 and 8).

First Fixations

Chi-square tests were conducted for each of the contrapposto stimuli to determine which side (low vs. high vdWHRs) has had more frequent first fixations. Results showed that in all angles except 90°, first fixations were more frequently on lower vdWHRs compared with higher ones (see Table 10 for details).

Table 7 Mean, SD, and post hoc comparison for fixation number for left and right sides of standing and contrapposto poses of different viewing angles for male participants

	Standing							Contrapposto						
	Left			Right				Left			Right			
	WHR	M	SD	WHR	M	SD	*p*	WHR	M	SD	WHR	M	SD	*p*
0° (frontal)	0.66	2.24	1.74	0.66	2.68	1.82	.441	0.51	5.92	3.48	0.84	1.52	1.76	.001
45° (front profile)	0.67	3.60	2.68	0.65	2.00	1.76	.004	0.64	4.44	2.66	0.83	1.52	1.45	.001
90° (side)	1.06	3.40	3.01	0.58	3.72	2.64	.625	1.14	3.48	2.14	0.60	3.12	1.67	.530
135° (back profile)	0.67	2.36	1.85	0.65	2.40	1.58	.938	0.82	2.16	2.29	0.53	4.32	3.94	.003
180° (posterior)	0.66	3.04	2.03	0.66	3.00	2.50	.948	0.84	1.28	1.57	0.51	6.72	4.09	.001
225° (back profile)	0.65	3.72	1.99	0.67	2.56	2.26	.039	0.83	1.40	1.55	0.64	4.12	3.13	.001
270° (side)	0.58	3.44	2.71	1.06	2.92	2.20	.445	0.60	3.44	2.97	1.14	3.32	2.34	.855
315° (front profile)	0.65	2.64	1.52	0.67	2.72	2.48	.892	0.53	3.60	3.30	0.82	1.96	1.62	.009

Table 8 Mean, SD, and post hoc comparison for fixation number for left and right sides of standing and contrapposto poses of different viewing angles for female participants

	Standing							Contrapposto						
	Left			Right				Left			Right			
	WHR	M	SD	WHR	M	SD	*p*	WHR	M	SD	WHR	M	SD	*p*
0° (frontal)	0.66	2.51	1.80	0.66	2.21	1.71	.487	0.51	3.81	2.12	0.84	1.53	1.64	.001
45° (front profile)	0.67	2.91	1.87	0.65	1.49	1.32	.001	0.64	2.95	2.14	0.83	0.88	1.05	.001
90° (side)	1.06	2.70	2.13	0.58	3.05	2.25	.485	1.14	2.40	2.03	0.60	2.49	1.75	.831
135° (back profile)	0.67	1.30	1.28	0.65	2.40	1.84	.007	0.82	1.60	1.62	0.53	2.84	1.79	.024
180° (posterior)	0.66	2.51	1.78	0.66	2.35	1.77	.728	0.84	1.00	1.18	0.51	4.60	2.29	.001
225° (back profile)	0.65	2.37	1.85	0.67	2.74	1.81	.378	0.83	0.98	1.34	0.64	2.86	1.97	.001
270° (side)	0.58	3.02	2.76	1.06	2.91	1.92	.823	0.60	2.88	1.72	1.14	1.95	1.88	.066
315° (front profile)	0.65	2.30	2.09	0.67	2.30	1.82	.998	0.53	3.05	2.00	0.82	2.05	1.75	.036

Table 9 Repeated-measures ANOVA testing the effect of participants' sex, body pose (standing and contrapposto), vdWHR (low vs. high), and eight viewing angles on fixation number

Source of variation	*df*	*F*	*p*	Partial η^2
Sex	1, 66	9.07	.004	.121
Pose	1, 66	2.54	.115	.037
vdWHR	1, 66	63.08	< .001	.489
Angle	7, 462	6.88	< .001	.094
Body Pose × Sex	1, 66	5.77	.019	.080
Body Pose × vdWHR	1, 66	104.44	< .001	.613
vdWHR × Sex	1, 66	3.32	.073	.048
Angle × Sex	7, 462	0.88	.516	.013
Body Pose × Angle	7, 462	6.39	< .001	.088
Angle × vdWHR	7, 462	7.97	< .001	.108
Body Pose × vdWHR × Sex	1, 66	3.74	.057	.054
Body Pose × Angle × Sex	7, 462	0.76	.616	.011
Angle × vdWHR × Sex	7, 462	0.42	.885	.006
Body Pose × Angle × vdWHR	7, 462	11.64	< .001	.150
Body Pose × Angle × vdWHR × Sex	7, 462	2.30	.026	.034

Table 10 Number of individuals who made their first fixations on left or right sides of contrapposto stimuli ($N = 68$)

	Left		Right		χ^2
	WHR	N	WHR	N	
0° (frontal)	0.51	66	0.84	2	94.54***
45° (front profile)	0.62	65	0.85	1	100.82***
90° (side)	1.14	32	0.61	36	1.25
135° (back profile)	0.90	9	0.50	57	58.29***
180° (posterior)	0.84	1	0.51	66	99.75***
225° (back profile)	0.80	1	0.66	65	94.49***
270° (side)	0.56	56	1.12	11	59.74***
315° (front profile)	0.54	66	0.80	1	115.01***

*** $p < .001$

Discussion

The concept of supernormal stimuli, stimuli whereby animals show greater responsiveness to stimuli that differ substantially from the animals' natural releasing stimuli, was introduced to the study of psychology and behavior from ethology more than seven decades ago (Ghirlanda & Enquist, 2003; Staddon, 1975; Tinbergen, 1948). Since then, researchers have investigated this effect for various human physical features. Results of this effect have been sought in the augmentation of facial features such as eyes, lips, and lower face roundness in self-portraiture (Costa & Corazza, 2006), the physical dimensions of breasts (Doyle & Pazhoohi, 2012), WHR silhouettes (Derenne et al., 2008), and photographs (Doyle, 2009a), in whole and isolated views of breasts, midriffs, and buttocks (Marković & Bulut, 2017), as well as from movement patterns such as walking gaits (Doyle, 2009a; Morris, White, Morrison, & Fisher, 2013), dancing (Doyle, 2010a), and proceptive movements (Pazhoohi, Doyle, Macedo, & Arantes, 2018).

Overall, the results of the current study showed that both men and women rated contrapposto stimuli as more attractive than standing stimuli and that ratings were higher for men than women. Both men and women had longer dwell times on lower rather than higher vdWHRs of contrapposto images, suggesting that curvier edges are looked at longer. Likewise, first fixations most frequently fell on the side of the contrapposto images containing the curvier edge (Fig. 2), highlighting the saliency of low-vdWHR sides compared with high sides. These low-sided vdWHRs were also fixated on more frequently by women and men than higher-sided vdWHR, suggesting that low-vdWHR curve regions repeatedly capture attention.

Given that the actual WHR of the model was not calculated but remained constant for all images, we conclude that lower vdWHRs are responsible for higher ratings of attractiveness. In "whole" view, measures of the standing vdWHR across the images in frontal and posterior views are approximately equal to the vdWHR of contrapposto pose in frontal and posterior views. Yet, in contrapposto pose, one of the two opposing sides is substantially lower than the other, as well as being lower than the standing-pose vdWHRs. The other, higher side of the contrapposto form is much higher than its opposing low side in addition to being higher than the vdWHRs of the standing stimuli. Taking into account that both sides of the standing vdWHR are nearly identical, but one side of the contrapposto pose shows a high vdWHR compared to the other side with an exaggeratedly low vdWHR, and also considering that this pattern of alternating low and high vdWHRs repeats for asymmetrical views (i.e., non-frontal or posterior views), we further conclude that contrasts between lower and higher vdWHR sides of the images contribute to higher attractiveness ratings, number of fixations, first fixations, and dwell times that the lower vdWHRs receive.

It has been hypothesized that men's preferences result from phylogenetic adaptation to women's sexually dimorphic "S-like" curves, the evolution of a gynoid pattern of fat distribution, wider childbearing hips, and bipedal locomotion (Pawłowski & Grabarczyk, 2003), as well as men's ontogenetically developed ability to discriminate reproductive-age women's shapes and movements from non-reproductively relevant stimuli that they are exposed to during development (Doyle, 2009b). One such behavioral manifestation is the phylogenetically conserved, lordotic, or "arched back" pose. Recent findings indicate that increases in the apparent curvature of the spine, like those observable during displays of proceptive behavior, are rated as more attractive, fixated on more, and looked at longer than less-arched backs (Pazhoohi et al., 2018). In this pose, variation in vdWHR is more apparent in side and posterior views than frontal views. In an artificial selection experiment, digital models were transformed along a number of physical dimensions and results showed that bodies transformed to be both more slender and shapely and it was the waist girth but not WHR that predicted attractiveness (Brooks, Shelly, Jordan, & Dixson, 2015). When the sex of figures is ambiguous, WHR serves to disambiguate feminine from masculine forms, with lower (< .74) line-drawn shapes being categorized by study participants as female (Pazhoohi & Liddle, 2012). If then, in natural environments, some women further behaviorally differentiate themselves from a population average for feminine characteristics, such as breast shape and/or vdWHR, they stand to benefit from these greater contrasts by dynamically creating peak shifts in the perceptions of attractiveness in men whose attention they seek to influence.

Moreover, the peak shift effect and supernormal WHR could serve as grounds for more systematic identification of attractive movements from unattractive ones. There are many instances of the effects of body movement on the perceived attractiveness

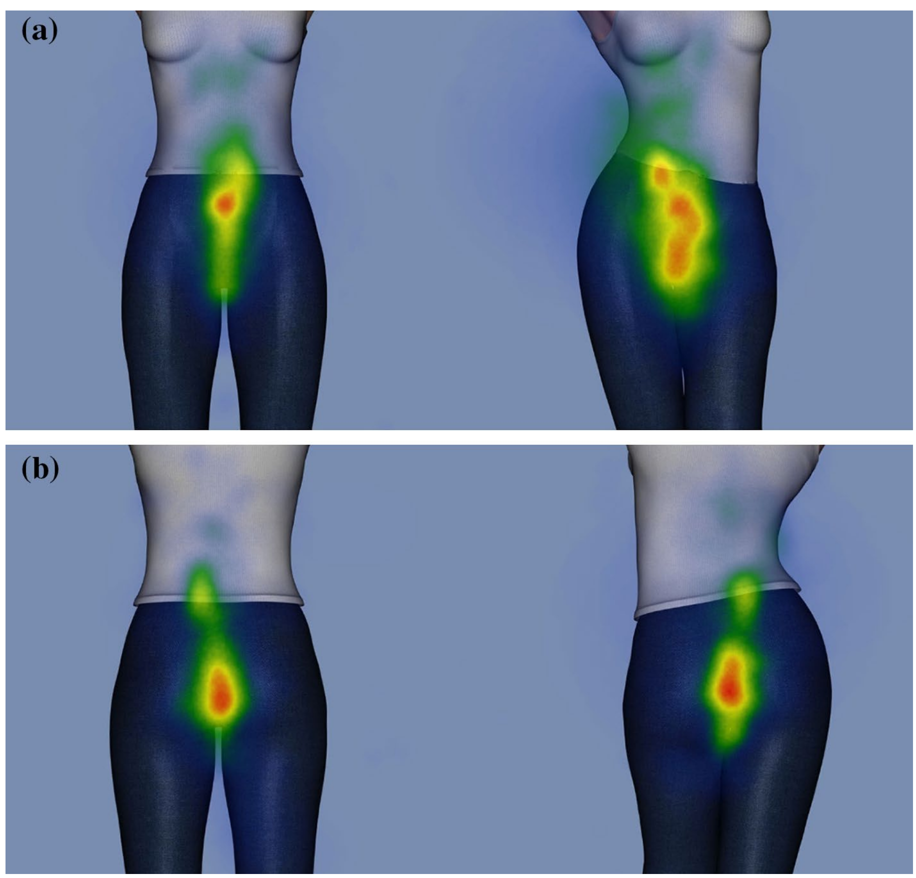

Fig. 2 Standing (left) and contrapposto (right) stimuli in **a** frontal and **b** back views

of bodies. For example, women's gaits are perceived as more attractive when wearing high-heel shoes (Guéguen, 2015; Morris et al., 2013) which enhance the lengths of their silhouette shapes and side-to-side movements (Doyle, 2009a). Also, women's dance movements are more attractive around ovulation (Fink, Hugill, & Lange, 2012; Miller, Tybur, & Jordan, 2007) and attractive dancers move differently than unattractive dancers and capture more attention (Röder et al., 2016). Even images of implied body motion are perceived as more attractive than images of static ones (Cazzato, Siega, & Urgesi, 2012). Recently, McCarty et al. (2017) showed that greater hip swing and thigh movement in women's dance was associated with higher perceived attractiveness. It could be that the frequency of appearing in contrapposto-like pose during dancing and sequences of juxtapositions of varying view-dependent WHRs are contributing factors to perceived attractiveness of gait and dance. Some such effect puts the allure of sensual dances (e.g., belly dancing) (Doyle, 2010a) into perspective as displays of lower-than-actual WHR postures, irrespective of an optimal WHR, that differentiate one from population average vdWHRs.

Previous studies have used various sets of stimuli that have been analyzed using incompatible definitions and measurements of WHR, sometimes with unlike body poses. Early WHR studies have used either contrapposto-like (Henss, 1995; Singh, 1993a; Singh & Luis, 1995) or standing body posture depictions of women (Tovée & Cornelissen, 2001; Tovée et al., 1999). This may have contributed to a lack of consensus over the relative importance of WHR, BMI, and other feminine characteristics on women's attractiveness (Tassinary & Hansen, 1998). Our results suggest not only that the perceived WHR-related attractiveness of a given WHR is not necessarily fixed and that perceptions vary depending on the viewer's position as well as the rotation and postural configuration of the model but also that the attractiveness of non-optimal WHRs has been mis-categorized by using static, less attractive poses rather than dynamic stimuli showing the allure of feminine pose and movement.

Results of the current experiment provide insight as to why, in artistic presentation, goddesses of beauty and love are often depicted in contrapposto pose and provide a basis for human artistic endeavors in creation of the artistic supernormal vdWHR from antiquity (e.g., female figurines ca. 3500 B.C.E from Tureng Tepe, Iran (32-41-25, Penn Museum) and Ma'mariya, Egypt (07.447.505, Brooklyn Museum), and Amlash terracotta female figurines ca. 3000 B.C.E from northern Iran) to the current time (e.g., fictional characters Jessica Rabbit, Tomb Raider's Lara Croft, and Catwoman). Furthermore, these results suggest a reason that sculptures of males and females from Indian, African, Greek, and Egyptian cultures have been shown to instantiate known, .90 male, and .70 female, sexually dimorphic WHR means (Singh, 2002, 2006). Given that actual WHRs cast vdWHR values to viewers, sculptors who create exaggeratedly low-WHR figures create greater contrasts between high and low vdWHRs or minimize high vdWHRs. For example, the low WHR of Parvati and Apsara figurines cast even lower across-vdWHRs and one-side-only vdWHRs that are lower still. These are all in contrast to sided vdWHRs that are higher than the figure's actual WHR. Perhaps it is artists' use of the peak shift principle that has resulted in memorable art observed throughout history, and perhaps, peak shifting is affecting selection criteria in cultures influenced by such art.

Since some studies suggest that BMI, versus WHR, is the primary and more important determinant of sexual attractiveness (Kościński, 2013; Tovée et al., 1999), we note that because digital images of model were used here, we were not able to measure body mass and BMI. Our approach used one model that had an unknown WHR that was held constant in both poses and at every viewing angle. This allowed manipulation of the view of the model and hence changed the perceived, but not actual, widths of the waist and hips. Establishing vdWHR as a tool for understanding attractiveness would position researchers to investigate WHR/BMI confounding (e.g., when model waist widths are individually altered) in new ways. Further experiments using models of real people with different BMIs could be used to investigate the role BMI plays in attractiveness and how vdWHR affects ratings of bodies with varying degrees of body fat.

In conclusion, the current results support that (1) the contrapposto pose is more attractive than the standing pose, (2) vdWHR ratings are view-dependent, (3) peak shifts are possible from WHR figures containing low vdWHRs, and (4) vdWHRs lower than the WHRs from which they derive are supernormal stimuli, as demonstrated here in a number of measurable eye-tracking behaviors. In other words, lower view-dependent WHRs are preferred over higher ones in terms of attractiveness ratings, first eye fixations, number of eye fixations, and dwell time. These are derived from but not the same as actual WHR. Their interaction by the altering what a viewer sees and by the changing perspective on the posed individual can create "supernormal stimuli" that peak shift perceptions of attractiveness and influence observers' behaviors such as by increasing viewing time and eye fixations.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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