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The Curse of Curves

Sex Differences in the Associations Between Body Shape and Pain Expression

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Abstract This study examines the associations between objective and subjective measurements and impressions of body shape and cold pressor pain reporting in healthy adults. On the basis of sexual selection theory (SST), we hypothesized that body characteristics that are universally preferred by the opposite sex—specifically, lower waist-to-hip ratios (WHR) in women and higher shoulder-to-hip ratios (SHR) in men—and characteristics (e.g., proportion of body fat in women) that infer attractiveness differently across cultures will correspond to higher experimental pain reporting in women and lower pain reporting in males. A convenience sample of young adults ($n=96$, 58 females, 18–24 years; mean age$=19.4$) was measured for body mass index (BMI), WHR, SHR, and subjective body impressions (SBI), along with cold pressor pain reporting. The findings showed that BMI was positively associated with WHR and less-positive SBI in both sexes. Consistent with SST, however, only BMI and WHR predicted variability in pain expression in women, whereas only SHR predicted variability in men. Subjective body impressions were positively associated with SHR among males and unrelated to WHR among females, yet only females showed a positive association between SBI and higher pain reporting. The findings suggest that sexually selected physical characteristics (WHR and SHR) and culturally influenced somatic (BMI) and psychological (SBI) indicators of attractiveness correspond with variability in pain reporting, potentially reflecting the general tendency for people to express clusters of sexually selected and culturally influenced traits that may include differential pain perception.

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It is well-established that biological sex modulates the human pain experience at the population level, as reflected by mean gender differences in pain measurements. Relative to males, females report greater prevalence, frequency, and duration of clinical pain and pain-related distress (Berkley 1997; Fillingim et al. 2000; Riley et al. 1998; Ruau et al. 2012; Unruh 1996). Likewise, experimental studies show that women report higher pain sensitivity associated with various types of noxious stimuli (e.g., ischemic, pressure, electrical, and thermal; Berkley 1997; Fillingim et al. 2000; Fillingim and Maixner 1996; Riley et al. 1998; Shinal and Fillingim 2007). The magnitude of these effects varies from moderate to large depending on sample size, nature of the stimulus, and whether pain sensitivity is indexed by nonverbal behaviors (e.g., certain body movements, facial grimace) or by verbal behaviors such as pain threshold and tolerance reports (Berkley 1997; Fillingim et al. 2009; Riley et al. 1998; Shinal and Fillingim 2007). We propose that gender differences in the nonverbal and verbal behavioral expression of pain may be understandable by Sexual Selection Theory (SST) and the omnibus thesis that males and females faced unique selection pressures for experiencing and demonstrating pain throughout human natural history (Vigil 2009a, b, 2011; Vigil and Coulombe 2010; Vigil and Strenth 2014). Thus, from this perspective, one basic hypothesis is that gender-related pain expression should correspond to the expression of other morphological, behavioral, and psychological concomitants of gender that are known to have resulted from sexual selection pressures, including the shapes of men's and women's bodies.

Sexual Selection and Body Shape

Sexual selection pressures are generally believed to have driven the existence of modern-day sexual dimorphisms in the physical appearance of males and females (Darwin 1859, 1871; Heid et al. 2010). Sexual selection is the process whereby natural selection influences the survival and/or reproductive success of males and females differently. Sexual selection can operate via *intersexual* selection pressures, such as mate preferences, or via *intrasexual* selection pressures, or competition with members of the same sex (Buss 1988; Trivers 1972). Examples of gender differences that are generally believed to have resulted from intersexual selection pressures include morphological distinctions in the shapes of men's and women's faces and torsos. For example, cross-cultural research generally shows that males report greater attraction to women with lower waist-to-hip ratios (WHRs: an hourglass figure), and that females report greater attraction to men with higher shoulder-to-hip ratios (SHRs: a V-shaped figure; Dixson et al. 2003; Frederick and Haselton 2007; Furnham et al. 2005; Hughes and Gallup 2003; Maisey et al. 1999; Singh 1994; Singh et al. 2010; Streeter and McBurney 2003). These preferences can vary somewhat across cultures (Swami et al. 2009) and they are contingent on numerous individual-level factors (e.g., one's own body shape: Price et al. 2013), but they are generally presumed to reduce the costs associated with choosing an unhealthy mate in varying environments (see Cashdan 2008; Geary 2010; Geary et al. 2004; Singh 1993, 2002).

In other words, greater reproductive success for women with lower WHRs and for men with higher SHRs explains why contemporary males and females show universal sexual dimorphisms in these components of body shape. Physical features that distinguish the bone structure of males' and females' faces and bodies (e.g., shape of the brow ridge, chin, hips, and shoulders) are typically referred to as hormone markers because they correspond to exposure to gonadal hormones such as testosterone and estradiol, particularly in utero and during puberty (Barber 1995; Collaer and Hines 1995; Johnston et al. 2001; Marečková et al. 2011; Styne 1994; Thornhill and Gangestad 1999). The attractiveness of other basic body characteristics, such as BMI, is more facultative, environment-dependent, learned, and contingent on numerous factors, such as the degree of social competitiveness (Cashdan 2008) and the abundance of food in the local environment (Anderson et al. 1992), thereby signifying the individual's health relative to that of their sexual competitors. A high BMI is associated with increased attractiveness, particularly in females, in environments where resources are scarce (Nelson and Morrison 2005; Swami and Tovée 2007; Swami et al. 2010; but see Ember et al. 2005) and socioeconomic status (SES) is low (Frederick et al. 2008), whereas high BMI has been linked to unattractiveness in populations where resources are relatively abundant (e.g., Cornelissen et al. 2009; Hume and Montgomerie 2001) and SES is high (Swami et al. 2010).

Sexual Selection and Pain Perception

Prototypical sex differences in the experience and demonstration of pain behaviors (e.g., verbal reports, facial grimaces) are likely not as closely related to intersexual selection pressures as is body shape because there is no direct evidence that either higher (in women) or lower (in men) pain behaviors, in and of themselves, are preferred mating traits. Recent social-signaling models from evolutionary psychology instead purport that gender differences in many heuristically expressive gestures, including reacting to and empathizing with others' pain, are likely the result of intrasexual selection pressures associated with how ancestral males and females interacted with their peers (Vigil 2007, 2008, 2009a, b, 2011; Vigil and Coulombe 2011; Vigil and Strenth 2014). According to Vigil's socio-relational framework of expressive behaviors (SRFB; Vigil 2009a), humans evolved the behavioral heuristics to selectively demonstrate "submissive" gestures such as pain expression and pain empathizing (costly altruism signals) in order to signal vulnerability and appeasement and, ultimately, *trustworthiness cues* toward intimate and familiar confidantes (Vigil 2007, 2009a; Vigil and Strenth 2014). Humans instead rely on the demonstration of "dominant" gestures for signaling empowerment attributes such as physical prowess, and subsequently on *capacity cues* for regulating (i.e., attracting and dissuading) interactions with less intimate affiliates.

Since females tend to form smaller, more consolidated, and more trusted peer network structures than males on average (Geary et al. 2003; Rose and Rudolph 2006; Taylor et al. 2000; Vigil 2007, 2008, 2009a), it logically follows that females would have evolved a heightened sensitivity for expressing pain as part of a suite of trustworthiness-demonstrating behaviors (e.g., internalizing and prosocial behaviors) for maintaining their more intimate and selective peer relationships. Lower levels of pain behaviors (e.g., lower reported pain intensity and higher reported pain threshold and tolerance) in males would then be interpretable as an example of the varied heuristic tendencies they evolved to demonstrate capacity cues for maintaining their less intimate and more fluid relationships. Thus, from this social-signaling perspective of pain behaviors, the sexually selected tendencies for males and females to form different types of peer network structures and to utilize specialized expressive styles for interacting with peers may also have driven contemporary gender differences in the heuristic expression of pain, distinctions that are undoubtedly reinforced by social learning (Vigil 2007, 2008, 2009a, b, 2011; Vigil and Coulombe 2011; Vigil and Strenth 2014).

One basic prediction from this thesis is that individual differences in pain reporting should correspond to a constellation of gender-related traits that confer attractiveness and are conventionally believed to have resulted from sexual selection processes. The concept that there should be systematic, natural relations between morphological and behavioral traits, including different components of body shape and pain expression in men and women, is shown in Fig. 1. As shown in Fig. 1, biological (i.e., chromosomal)

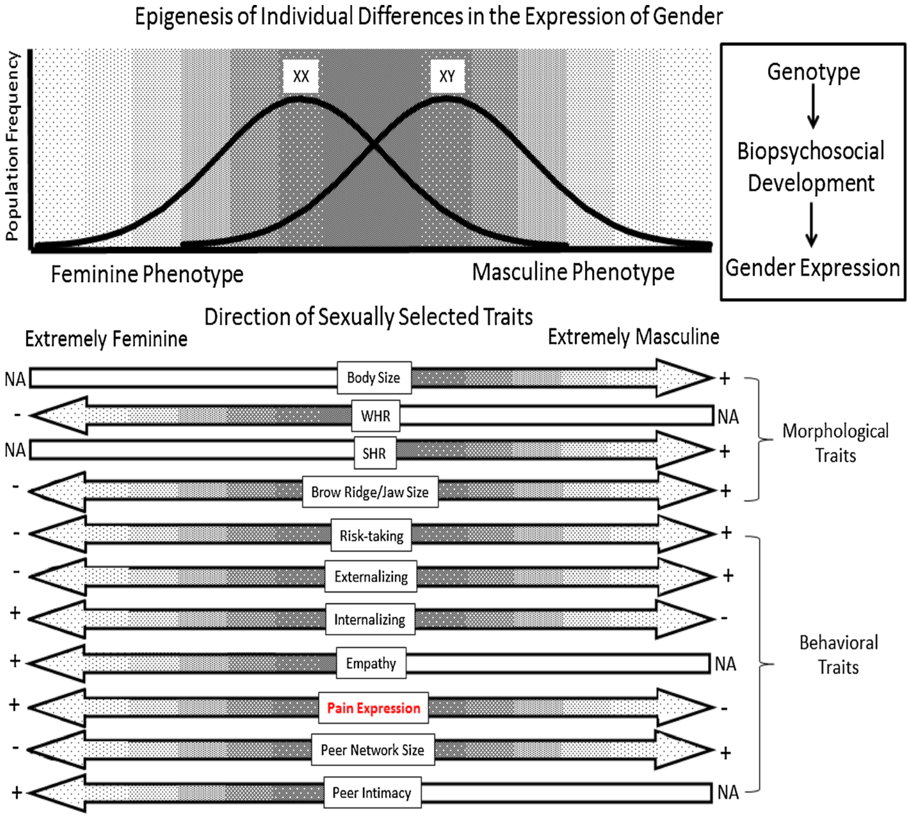

Fig. 1 Individual differences in the expression of gender have resulted from a cascade of phylogenetic, epigenetic, and ontogenetic (e.g., neuroendocrine, environmental, and social learning) factors. Sexual selection pressures produce a multitude of intercorrelated morphological and behavioral characteristics that are broadly expressed at different frequencies in the population. Arrows indicate the direction of sexual selection pressures for males and females, plus (+) and minus (−) signs indicate relatively higher and lower levels (respectively), and shading indicates the relative frequencies that each cluster of corresponding traits are expressed in nature

sex predisposes males and females to express a suite of sexually selected characteristics within a range of reactivity. Variability in genetic dispositions subsequently interact with ontogenetic processes (e.g., prenatal and postnatal gonadal hormone exposure, social environments, and learned experiences) to produce clusters of inter-correlated concomitants of gender expression within each sex. On the basis of this thesis, males and females with different gender profiles should evidence multiple phenotypes that share a similar magnitude of sexual specialization (e.g., level of masculinity/femininity) and relative frequency across the population (see Cashdan 2008).

Current Study

Despite a growing body of literature on numerous psychological correlates of gender expression, such as dispositional femininity/masculinity and pain reporting (Bernardes et al. 2008; Myers et al. 2001; Vigil et al. 2013), surprisingly little research has been conducted on how basic morphological attributes may be associated with the expression of pain. Previous research thus far has demonstrated mixed findings on how basic somatic characteristics such as BMI may covary with experimental pain reporting; some human and non-human animal research has found a positive association between obesity and pain reporting (McKendall and Haier 1983; Zhang et al. 2013), whereas other studies report the inverse association (Khimich 1997; Ramzan et al. 1993; Zahorska-Markiewicz et al. 1988). In another study examining sex differences, researchers found that shorter women reported greater pain, but neither weight nor BMI were related to pain behaviors in males or females (Tashani et al. 2010). Certainly, methodological factors (e.g., characteristics of samples, nature of noxious stimuli) and contextual factors (e.g., characteristics of other people in laboratory setting) have contributed to these discrepancies (see Vigil and Strenth 2014).

The current study examines the hypothesis that if gender differences in pain expression resulted from sexual selection forces, then individual differences in experimental pain reporting should broadly correlate with objective measurements of body shape differently in men and women. Under the foundation of SST, we hypothesize that sexually selected and hence universally preferred (attractive) body shapes—specifically lower WHR in females and higher SHR in males—would correlate with higher pain reporting in women, and with lower pain reporting among men. Additionally, we expected that bodily characteristics that confer beauty in males and females differently across cultures, such as BMI, would also correspond to pain reporting. This hypothesis is based on the premise that humans rely on both sexually selected traits (e.g., WHR, SHR, and pain expression) and learned information (e.g., social reinforcement) to construct gender roles, and on research showing that gender roles can influence pain reporting (e.g., Robinson et al. 2003). Given that lower BMI is more closely linked to peer-evaluated attractiveness for women than it is for men in competitive (e.g., Western) societies where resources are abundant (Anderson et al. 1992; Cashdan 2008), it makes sense that women with a lower BMI may consider themselves as having more “feminine” characteristics or gonadal profiles in general and either implicitly or explicitly adopt more exaggerated gender behaviors, including heightened pain expression.

We also explore the role of subjective body impressions (SBI) so as to contrast the roles of perceptions of physical characteristics with objective body measurements on experimental pain reports. For women in the US and many other cultures, BMI is a robust negative predictor of body dissatisfaction (Frederick et al. 2007; Swami et al. 2010), with the exception of certain races (African American), where this association has been shown to be either not as strong or nonexistent (e.g., Chithambo and Huey 2013). Overweight men likewise perceive themselves as more attractive than do overweight women, whereas underweight men perceive themselves as less attractive than do underweight women (McCreary and Sadava 2001). We therefore expected that subjective impressions of one's own body shape would correlate with greater pain behaviors, particularly among women, based on evidence that physical attractiveness is more instrumental for men's mate preferences (Buss 1989; Buss et al. 2001; Confer et al. 2010; Geary et al. 2004) and more closely tied to women's self-esteem (Harter 1999; Wade 2000) and likely gender (profile) identities.

Methods

Participants

The protocol was approved by the University of New Mexico's Institutional Review Board, and two forms of written consent were obtained from all participants. The first consent form described the general experimental protocol, and the second described the cold pressor pain task (CPT) in more detail. Participants were a convenience sample of college students who received course credit for their participation. Participants who self-identified contraindication(s) to the CPT were excluded from the study. Contraindications included any illness related to a cardiovascular disorder (e.g., high blood pressure, heart disease, or dysrhythmia); history of fainting or seizures; history of frostbite; having an open cut, sore, or bone fracture on the limb to be immersed in water; or a history of Reynaud's phenomenon. The sample consisted of 96 healthy young adults (18–24 years, mean age=19.4, SD=1.6, 58 females; 35% Non-Hispanic White; 45% Hispanic/Latin; 20% other ethnicity).

Procedures

Participants were assisted through the experimental protocol by one of ten research assistants: four self-identified males and six self-identified females (50% Hispanic/Latin-American, 50% non-Hispanic White). The researchers followed a script for every phase of the experiment to minimize the possible influence of interpersonal factors (e.g., quantity and quality of semantic information, conversation styles) associated with the researchers' characteristics. Following the informed consent procedure, participants were measured for height, weight, shoulder, waist, and hip circumferences; this took 5 to 10 min. Body mass was calculated with a standard formula (weight in lbs/height in inches^2 × 703). Participants were then escorted to an assessment room where they were left alone to complete a background questionnaire and to view a video that provided instructions for performing the CPT without a researcher present. The video provided directions for using the cold pressor apparatus and indicated various pain ratings. The survey and instructional video took approximately 30 min to complete.

Once participants completed watching the instructional video, they were led into the room with the cold pressor apparatus. The cold pressor room was fitted with a video camera for viewing the participants from a remote location, a cold pressor apparatus, and a laptop programmed with user-interfaced pain assessment software. The computer program was used to electronically measure participants' time latency for when they first subjectively felt a discomfort sensation, when the discomfort sensation transitioned into a painful sensation (pain threshold), and when they chose to discontinue the task because they were unable or unwilling to tolerate the pain as described below. The participants were instructed to begin the task once the researcher left the CPT room. The participant then carried out the CPT without a researcher present, and the researcher observed the participant through a live video feed from the next room to ensure adherence to the cold pressor procedure. This protocol enabled researchers to collect CPT data without being physically present during the CPT, which has been shown to influence experimental pain reporting (Kállai et al. 2004; Levine and De Simone 1991; Vigil and Coulombe 2011). Following the cold pressor task individuals were debriefed.

Questionnaires

A basic questionnaire created by our lab evaluated major demographics such as sex, age, ethnicity, family background (not used in the current analyses), and subjective ratings of one's appearance. The ratings consisted of five items from the Body-Esteem Scale (Franzoi and Shields 1984) asking participants to describe their feelings about the appearance of their *waist*, *body build*, *physique or figure*, *stomach*, and *weight*, respectively (coded from 1 to 5, from having *strong negative feelings* to having *strong positive feelings*). The items were chosen because they encompassed impressions of the appearance of one's body shape (e.g., rather than energy level or appetite), and they were aggregated to compute a subjective body impressions variable ($\alpha_{\text{males}}=0.84$, $\alpha_{\text{females}}=0.93$).

Cold Pressor Task

Apparatus Participants were seated in a chair between the pressor apparatus (left side) and the laptop computer (right side) in a small room (2.0×2.5 m). The mechanical CPT device was an Isotemp 6200R28 refrigerated bath circulator (reservoir size: 11.0″× 6.5″×8.8″). This machine circulates water automatically and maintains a consistent temperature by dual heating and cooling actions. The water temperature was set to 5 °C (known to produce a range of pain tolerance levels with only minimal ceiling effects; von Baeyer et al. 2005). Small differences in water temperature (2 °C) can have significant effects on pain sensitivity measures (Mitchell et al. 2004), and all the participants in the current study experienced water temperatures within 0.5 °C of the target temperature.

Procedures The pain assessment program (on the laptop) displayed an initial screen with the general CPT instructions. The researcher verbally reiterated the instructions by describing that when participants chose to both begin and end the task (at maximum pain tolerance) they were to perform two simultaneous actions. To begin the task (and initiate the pain assessment program), participants were instructed to first indicate their baseline (pre-manipulation) pain severity along a standard visual analog scale (VAS: 0–10, from no pain to worst pain imaginable), while simultaneously submerging their left hand into the cold water to a marked line on the wrist (1″ above the wrist joint). To end the task, participants were instructed to indicate this preference (pain tolerance) electronically by clicking on a corresponding icon on the computer screen while simultaneously lifting their hand out of the cold pressor apparatus. Participants were also instructed to immediately indicate when they first experienced a discomfort sensation (discomfort threshold) and a pain sensation (pain threshold).

After an indication of instructional comprehension, the participants were fitted with a finger pulsometer to monitor their heart rate during the CPT. Lastly the researcher reminded the participants that they would be recorded, and that they should begin at their convenience. The researcher then left the cold pressor room and closed the door. The procedure was observed on a video monitor from another room, and the researcher returned to the experimental room to debrief the participants once they retracted their hand from the water or after the maximum duration of 5 min had occurred (the participants were not informed of this time limit). Following debriefing, participants were asked to rest for 5 min to ensure they no longer felt any physical discomfort from involvement in the study and that their heart rate had returned to resting.

Data Analyses

The pain scores consisted of three conventional types of pain reports, each signifying a heightened experience and expression of pain: the participant's self-reported discomfort threshold, pain threshold, and pain tolerance (measured in time latency post-submersion). Lower threshold and tolerance scores are interpreted as indicating greater CPT pain expression in sequential order at different phases (e.g., beginning, middle, and end) of the CPT. Analyses of Covariances (ANCOVAs) were used to examine gender differences in the body measurements and pain scores, and multiple regressions were used to examine how participant's gender may interact with body measurements to predict pain scores. Given previous research demonstrating ethnic differences in pain reporting (e.g., Campbell and Edwards 2012; Lu et al. 2013; Rahim-Williams et al. 2012; Rowell et al. 2011), the participant's ethnicity and baseline (pre-manipulation) pain scores and the examiner's gender were entered as covariates. Bivariate correlations and partial correlations were likewise used to examine the simple associations between the variables.

Results

Sex Differences in Body Measurements and Pain Sensitivity

The WHR measurements ranged from 0.60 to 1.47 (M=0.86) for males and 0.70 to 0.94 (M=0.77) for females; the SHR measurements ranged from 1.05 to 1.33 (M=1.18) for males and 0.65 to 1.19 (M=1.03) for females. BMI measurements ranged from

17.35 to 48.15 (M=23.83) for males and 15.46 to 43.47 (M=23.76) for females; and the SBI measurements ranged from 6 to 25 (M=16.97) for males and 5 to 25 (M=15.70) for females. Independent samples t tests revealed robust gender differences for WHR, $t_{94}=4.49$, $d=0.87$, $p<0.001$, and for SHR, $t_{94}=7.84$, $d=1.67$, $p<0.001$. There were no differences for BMI, $t_{92}=0.065$, $d=0.01$, $p=0.948$, or SBI, $t_{92}=1.26$, $d=0.27$, $p=0.212$. A series of ANCOVAs examining gender differences in the pain scores (controlling for participant's ethnicity and baseline pain scores and the experimenter's gender) found a significant sex difference for pain tolerance, $F_{1,88}=5.42$, $p=0.022$, $\eta_p^2=0.058$, but not for discomfort threshold, $F_{1,87}<1$, $p=0.389$, $\eta_p^2=0.009$, or pain threshold, $F_{1,83}<1$, $p=0.920$, $\eta_p^2<0.001$.

Associations between Objective Body Measurements and Pain Reports

Partial correlations (controlling for ethnicity and baseline pain and the experimenter's gender) between body measurements and the pain scores for males and females are shown in Table 1. Next, a series of regressions was performed for each of the three pain scores (discomfort threshold, pain threshold, and pain tolerance) using the WHR (waist circumference/hip circumference), Participant Gender (males coded −0.5, females coded+0.5), and the WHR × Participant Gender interaction terms as predictor variables (entering ethnicity, baseline pain, and experimenter's gender as covariates). Additional equations were then run to examine how participants' SHRs (shoulder circumference/hip circumference) and BMIs predicted each of the pain scores. The equations pertaining to WHR showed a significant WHR × Participant Gender interaction term for pain threshold, ($R^2=0.12$, $\beta=0.34$, $p=0.007$). Follow-up analyses examining the association between WHRs and pain thresholds separately for females and males (controlling for ethnicity, baseline pain, and experimenter's gender) also showed a significant main effect for pain threshold in females only, $\beta=0.33$, $p=0.021$ (see Table 1); the effect of WHR on pain threshold was not significant among men ($p=0.936$). The interaction term and main effect terms for WHR failed to reach significance for the equations pertaining to discomfort threshold and pain tolerance (p values>0.10).

The equations pertaining to SHR showed a trend for a significant SHR × Participant Gender interaction term for discomfort threshold ($R^2=0.10$, $\beta=-0.21$, $p=0.073$). Follow-up analyses examining the association between SHRs and discomfort thresholds separately for females and males (controlling for ethnicity, baseline pain, and experimenter's gender) showed a significant main effect for pain threshold in males only, $\beta=0.41$, $p=0.006$; as shown in Table 1, the effect of participants' SHR on pain threshold was not significant among females ($p=0.768$). The interaction term and main effect terms for SHR failed to reach significance for the equations pertaining to pain threshold and pain tolerance (p values>0.10).

The equations pertaining to BMI showed a significant BMI × Participant Gender interaction term for pain threshold ($R^2=0.25$, $\beta=0.33$, $p=0.002$) and pain tolerance ($R^2=0.27$, $\beta=0.30$, $p=0.002$). The interaction term for BMI failed to reach significance for the equation pertaining to discomfort threshold ($p>0.10$); however, the main effect term for this equation was significant ($R^2=0.10$, $\beta=0.22$, $p=0.047$). Follow-up analyses examining the association between BMI and pain threshold separately for females and males (controlling for the covariates) showed a significant main effect for BMI for pain threshold in females only, $\beta=0.51$, $p<0.001$; a similar effect was also found for

Table 1 Associations between objective and subjective body measurements and pain sensitivity in males and females

	Partial Correlations											
	1		2		3		4		5		6	
	M	F	M	F	M	F	M	F	M	F	M	F
1. BMI	–	–										
2. WHR	0.77**	0.44**	–	–								
3. SHR	−0.22	−0.24^{+}	0.03	0.22	–	–						
4. Body Impressions	−0.37*	−0.58**	−0.20	−0.10	0.55**	0.16	–	–				
5. Discomfort Threshold	0.07	0.30*	0.02	0.13	0.31^{+}	0.04	0.22	−0.12	–	–		
6. Pain Threshold	0.02	0.51**	−0.02	0.32*	0.15	−0.06	0.11	−0.20	0.78**	0.62**	–	–
7. Pain Tolerance	−0.17	0.48**	−0.02	0.27^{+}	−0.11	0.02	−0.01	−0.37**	0.42*	0.45**	0.51**	0.68**

BMI body mass index, *WHR* waist-to-hip ratio, and *SHR* shoulder-to-hip ratio are objective body measures

Body Impression is subjective. The values are partial correlations, controlling for baseline pain levels and examiner's gender

*$p<0.05$, **$p<0.01$

pain tolerance in females only, $\beta=0.44$, $p=0.001$. As shown in Table 1, the effects of BMI on pain threshold and pain tolerance were not significant for males (p values> 0.10).

Associations between Subjective Body Impressions and Pain Reports

Finally, Table 1 shows that SBI was negatively correlated with BMI and positively correlated with SHR in males. In females, SBI was negatively correlated with BMI, but it was not correlated with either WHR or SHR. The final set of regressions pertaining to SBI failed to show significant SBI × Participant Gender interaction or main effect terms for SBI for discomfort threshold ($R^2=0.07$, p values=0.08 and 0.53, respectively), pain threshold ($R^2=0.07$, p values=0.15 and 0.64), or pain tolerance ($R^2=0.20$, p values= 0.12 and 0.23). However, as shown in Table 1, SBI showed a moderate inverse relationship with pain tolerance in females only, $\beta=-0.35$, $p=0.011$, after controlling for the participants' ethnicity and baseline pain and the gender of the experimenter.

Discussion

The current study extends previous research on morphological characteristics and pain behaviors (Tashani et al. 2010; Zhang et al. 2013) by showing for the first time that sexually selected characteristics of body shape (WHR and SHR) that confer universally attractive body shapes to the opposite sex are associated with differential cold pressor pain reporting in healthy, young women and men. Moreover, a very basic bodily characteristic that confers beauty in variable, culturally dependent ways—namely, BMI—was also found to correspond to sex differences in pain reporting, suggesting that some explicitly learned (socially reinforced) information about one's attractiveness (and perhaps ideals of happiness; see Evans 2003) may contribute to gender roles in ways that influence pain expression. Specifically, we found that BMI was positively associated with WHR and less-positive SBI in both sexes, as well as variability in pain reporting, especially among women. Waist-to-hip ratio was also predictive of variability in pain reporting in women, whereas SHR was associated with variable pain reporting, but only among men. Likewise, although participants' subjective body impressions were positively associated with SHR among males and unrelated to WHR among females, only females showed a positive association between SBI and pain reporting. Taken together, the findings suggest that individual differences in pain expression (indicated in the current study by self-reported pain threshold and tolerance measurements) are expressed along a continuum that corresponds to the expression of other normally distributed sexually selected traits and culturally reinforced components of body attractiveness in men and women.

These findings are interpretable from the perspective that individual differences in pain behaviors correspond to the general tendency for people to express a cluster of inter-correlated morphological and behavioral characteristics that have resulted from sexual selection processes throughout humans' natural history. It is generally believed that intersexual selection pressures, such as prototypical mate preferences of the opposite sex, have driven sexual dimorphisms in body shapes and some types of signaling behaviors (e.g., facultative commitment cues) and social-processing proclivities (detection of facial attractiveness). It is likely, however, that the majority of sexually dimorphic expressive tendencies in males and females (e.g., externalizing vs. internalizing behaviors, over- vs. under-confidence gestures, lower vs. higher levels of empathizing and pain behaviors), as well as sex differences in numerous social-processing proficiencies (e.g., facial emotion recognition; see Donges et al. 2012; Hall and Matsumoto 2004; Herlitz and Lovén 2013; Hoffmann et al. 2010; Xu et al. 2013), are more directly the result of intrasexual selection pressures for creating and maintaining distinct peer network structures and for using unique communication styles for interacting with peers (Geary et al. 2003; Vigil 2007, 2008, 2009a). From the perspective of Vigil's social-relational framework of expressive behaviors (Vigil 2009a), sex differences in heuristic signaling styles are rooted in the basic tendency for humans to display capacity cues or dominant gestures (e.g., displays of physical prowess, confidence, independence, and pain tolerance) for attracting and regulating relationships with less-intimate affiliates and for maintaining larger peer-network structures. People instead rely on trustworthiness cues or submissive gestures (crying, worrying, apologizing, empathizing, pain expression) for negotiating relationships with more intimate, familiar, and reliable affiliates, and for maintaining smaller, more cohesive peer networks (e.g., Vigil 2007).

Sex differences in the tendencies for men and women to demonstrate higher levels of capacity cues versus trustworthiness cues, respectively, can then be explained from an evolutionary history of male-male coalitional competition and male-biased philopatry. In this type of social system, males were more likely to remain in their natal group in order to form large kin-based coalitions, while females tended to emigrate to the natal groups of their husbands upon sexual maturation (Geary 2002; Geary and Flinn 2001; Geary et al. 2003). Greater reliance on non-kin and more distantly related kin would have created the unique (intrasexual) selection pressures for females to be more discriminative and to restrict with whom they are willing to interact (resulting in heightened social processing skills and smaller social network structures) and to rely more heavily on the presentation of trustworthiness cues (costly altruism signaling) for strengthening the security and reliability of their peer relationships in the absence of strong inclusive bonds (Vigil 2007, 2009a). For males, instead, male-biased philopatry would have relaxed the selection pressures to advertise trustworthiness gestures in favor of capacity cues for attracting and maintaining larger, more fluid and instrumentally oriented coalitions of kin-related peers. This framework explains the general tendencies for females to form more consolidated and intimate peer relationships than males (Geary et al. 2003; Rose and Rudolph 2006; Taylor et al. 2000; Vigil 2007, 2008), and to express higher levels of appeasement and vulnerability gestures (e.g., crying, laughter, interpersonal mimicry, touching behaviors, sustained eye contact) that effectively disarm threat impressions and project impressions of trustworthiness to others (Becht and Vingerhoets 2002; Provine 1993; Vigil 2009a).

From this perspective, it makes sense that females and males would show sexual dimorphisms in many domains of self-expression, including nonverbal behaviors (e.g., body movement patterns, vocal prosody, mood behaviors) and subjective judgments and impressions about both internal (e.g., self-esteem) and external stimuli (Davis et al. 1999; Kling et al. 1999; Vigil 2009a). Sex differences in the expression of pain and pain empathizing behaviors (i.e., displays of vulnerability and appeasement) fit this pattern and the general hypothesis that females are more sensitive to interchange trustworthiness cues for maintaining their more consolidated and intimate network structures (Vigil 2008, 2009b; Vigil and Coulombe 2011; Vigil and Strenth 2014). This hypothesis is consistent with recent findings that people express pain differently to male and female audiences (e.g., medical staff and experimenters), and men and women share distinct associations between core elements of their social experiences (e.g., quantity and quality of intimate relationships) and experimental pain reporting (Vigil 2011; Vigil and Alcock 2014; Vigil and Coulombe 2011; Vigil et al. 2014a, c; 2014d).

The thesis that mean gender differences in pain expression reflect sexually selected traits explains why only women showed a positive correlation between a morphological characteristic (i.e., lower WHR) that is universally preferred by men (e.g., Singh et al. 2010) and higher pain reporting, whereas only men showed a correlation between higher SHR, which is universally preferred by women (e.g., Dixson et al. 2003), and lower pain reporting. The finding that BMI, which is based heavily on the acquisition of adipose tissue in addition to genetic bone structure, was also correlated with higher pain reporting (especially in women) highlights the possibility that socially reinforced information about one's appearance operates alongside individuals' gonadal profiles to contribute to gender role formation in ways that influence pain reporting. A lower BMI shares a stronger correlation with attractiveness for women than for men in Western societies (Anderson et al. 1992; Cashdan 2008), and subjective body impressions are highly reinforced by social learning and comparisons (e.g., gender modeling; Barlett et al. 2005; Groesz et al. 2002; Hargreaves and Tiggemann 2002; Patrick et al. 2004). It is therefore reasonable to hypothesize that people who place a stronger emphasis on personal looks for sexual appeal may also be more likely to exaggerate the expression of sexually selected behaviors as part of a broader gender profile (see also Cashdan 2008). Women who perceive themselves to be more attractive may adopt more feminine gender roles, and women who perceive themselves to be less attractive may instead adopt a more masculine gender profile, characterized by shifts in the expression of capacity/trustworthiness gestures and corresponding changes in peer network structures (e.g., from smaller to larger). This hypothesis is consistent with the currently observed correlations between women's subjective body impressions and variability in pain reporting. Numerous previous studies have likewise shown that variability in gender expression (e.g., trait masculinity/femininity and sexual orientation) and the manipulation of gender role expectations influence pain reporting (e.g., Defrin et al. 2009; Robinson et al. 2003; Vigil et al. 2014b).

Consistent with previous research (Frederick et al. 2007; McCreary and Sadava 2001; Swami et al. 2010), we found that BMI was associated with less-positive impressions about one's body in both sexes. Also consistent with previous research (e.g., Pazhoohi et al. 2012), we found that SBI was positively correlated with an objective indicator of body attractiveness in men—namely, SHR—whereas no correlation was found between SBI and the corresponding sexually selected trait (i.e., WHR) in women. Specifically, the females in this sample showed a significant association between their SBI and lower BMI, but no relationship was observed between their SBI and WHR. These findings are consistent with the wider literature on body image showing that females associate a positive body image with low BMI (e.g., thinness) and males associate a positive body image with high SHR (e.g., muscularity: Barlett et al. 2005; Cohane and Pope 2001; Hargreaves and Tiggemann 2006; McCreary 2002).

The interesting discordance between women's WHR and impressions of body attractiveness may stem from the fear of having a misshaped and less desirable body shape (e.g., pear-shaped). The discordance may also be interpreted as an example of the heuristic tendency for females to present more modest self-descriptions than males in ways that ultimately convey trustworthiness cues to others, similar to sex differences in the reporting of negative life experiences and self-esteem (Davis et al. 1999; Kling et al. 1999; Pinquart and Sörensen 2006; Tolin and Foa 2006; Vigil 2009a). Women's self-ratings of attractiveness are often found to be lower than how other people rate their attractiveness (and how they think other people would rate their attractiveness), and these perceptions are strongly related to both universal and culturally specific indicators of attractiveness, such as BMI (Dijkstra and Barelds 2011; Swami et al. 2010). Evolutionarily speaking, greater validity of male's impressions of their physiques, relative to those of females, may also be adaptive because males are more likely to engage in physical competition, and thus the risks associated with inaccurate impressions of one's competitive advantage are greater than the relative risks that females may incur. Likewise, the lack of an association between men's subjective body impressions and pain reporting may reflect the lower evolutionary importance of physical attractiveness for males' reproductive success, in which case a weaker link is expected between subjective body impressions and variability in gender-concordant behaviors, such as lower pain reporting.

In addition to these basic implications, a discussion of the study's limitations is warranted. First, the sample consisted only of Western, undergraduate students, which may not be representative of people from other cultures and people at different ages with more diverse backgrounds. The relatively small sample size may have also limited the stability of the findings (see Schönbrodt and Perugini 2013), potentially contributing to inconsistency in the patterns observed (e.g., correlations between different body and pain measurements). Some research has found that abdominal depth and waist circumference are stronger predictors of female attractiveness than WHR and BMI (Rilling et al. 2009), and future research may consider these distinctions in the context of sexual selection theory. Other methodological limitations were the use of a truncated measure of body self-esteem and the lack of controlling for handedness, which is known to influence CPT measurements (Pud et al. 2009). Similarly, menstrual functioning, though not controlled in the present study, has been shown to interact with numerous social experiential (e.g., pair-bond status) and contextual (e.g., gender of experimenter) factors to influence pain reporting in women (Vigil et al. 2014c; Vigil unpublished data). Additional procedural limitations include the possibility that (*a*) reactions to the discomfort task might not predict reactions to other forms of painful and non-painful stimuli; (*b*) self-reports of physical traits might be influenced by current affect; and (*c*) initial floor effects may confound laboratory discomfort tasks in which felt pain graduates from being nonexistent to being unbearable. Although we tried to eliminate the potential influence of observer effects, it is still possible that people responded to the virtual presence of the (remote) experimenter in ways that confounded the ability to examine our proposed hypotheses. Likewise, since the study is cross-sectional, the presumed influence of sexual selection processes (e.g., mate and peer preferences) on the expression of both body shape and pain expression can only be considered tentative, and genetic studies may help substantiate this hypothesis.

Another possibility is that the findings were influenced by proximate, behavioral factors such as differential exposure to painful experiences and/or social feedback. It is plausible, for instance, that males with higher SHRs are more likely to be exposed to painful stimuli (e.g., resulting in habituation of nociceptive input) or to have experienced lower levels of solicitous, responses and hence lower levels of reinforcing behaviors from others. Similarly, physically attractive women may be more sheltered from painful events than less attractive women, and men and attractive women may be more likely to experience sympathy from others. People that endorse stronger gender roles may also involuntarily or voluntarily engage in activities (e.g., pain concealment and increased bodybuilding, which may result in higher SHRs) that may partially explain the current findings (e.g., see McCreary et al. 2007). Such possibilities are still consistent with the social-signaling perspective of pain expression and the general thesis that males and females utilize pain behaviors in somewhat specialized and selective ways for regulating their peer relationships (Vigil 2009b, 2011; Vigil and Coulombe 2011; Vigil and Strenth 2014). Future research will benefit from investigations of sex differences in pain expression in relation to individual differences in gonadal gender profiles, attentional regulation, and nociceptive processes involved in pain expression (e.g., Park et al. 2012).

In conclusion, basic sex differences in pain behaviors highlight an interesting sexual dimorphism that has yet to be fully addressed in the context of evolutionary psychology, despite its tremendous societal and medical importance. Our findings extend research on various topical evolutionary constructs (e.g., sexual health, fertility, and sexual attractiveness) by showing that females with more feminine physiques and females with heightened psychological senses of personal sex appeal express higher pain levels than females without these characteristics. Males with masculine physiques instead express dampened pain behaviors, thereby evidencing functional specialization. Should future research confirm this observation, these results may have important implications for understanding the determinants of individual differences in pain perception and for guiding individualized pain treatment options. Future research will benefit by comparing additional physical and psychological features associated with endocrine functioning (e.g., facial hormone markers, pain empathizing) along with the individual's social environment (e.g., structure and intimacy of peer networks) so as to illuminate important distinctions across individuals. A primary function of gonadal sex hormones, such as testosterone and estrogen, is to achieve the appearance of socially preferred characteristics. In this manner it can be understood that sex differences in pain expression remain influenced by endocrine functions responsible for the ontogeny of a multitude of sexual characteristics, heretofore referred to as gender profiles. Future research on individual differences in gender expression may yield significant insight when examining, comparing, and interpreting individual differences in experimental pain performance and clinical pain experiences.

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