

Anthropometric Correlates of Human Anger

Running headline: Anthropometric Correlates of Anger

Michael E. Price, Department of Psychology, Brunel University

James Dunn, Department of Psychology, Brunel University

Sian Hopkins, Department of Psychology, Brunel University

Jinsheng Kang, School of Engineering and Design, Brunel University

Correspondence concerning this article should be addressed to:

Michael E. Price

Department of Psychology

School of Social Sciences

Brunel University

Uxbridge, Middlesex

UB8 3PH

United Kingdom

E-mail: michael.price@brunel.ac.uk

WORD COUNT (includes abstract, main text and references): 5,469

1 **Abstract**

2

3 The recalibrational theory of human anger predicts positive correlations between aggressive
4 formidability and anger levels in males, and between physical attractiveness and anger levels
5 in females. We tested these predictions by using a three dimensional body scanner to collect
6 anthropometric data about male aggressive formidability (measures of upper body
7 muscularity and leg-body ratio) and female bodily attractiveness (waist-hip ratio, body mass
8 index, overall body shape femininity, and several other measures). Predictions were partially
9 supported: in males, two of three anger measures correlated significantly positively with
10 several muscularity measures; in females, self-perceived attractiveness correlated
11 significantly positively with two anger measures. However, most of these significant results
12 were observed only after excluding from the sample 27 participants who were older than
13 undergraduate age, leaving a subsample of 40 males and 51 females. Evidence for
14 relationships between anthropometric attractiveness indicators and anger measures was weak,
15 but there was some evidence for relationships between anthropometric attractiveness
16 indicators and self-perceived attractiveness measures. While our results support the
17 recalibrational theory's prediction that anger usage and formidability are positively correlated
18 in males, and suggest that this formidability can be assessed via anthropometric measures
19 alone, they also suggest that this prediction may not apply to populations older than
20 undergraduate age. Further, our results suggest that while female anger levels relate
21 positively to self-perceived attractiveness, they are unrelated to most anthropometric
22 measures of bodily attractiveness.

23 *Keywords:* recalibrational theory; anger; aggression; self-perceived physical attractiveness;
24 muscularity; evolutionary psychology

25

26 **1. Introduction**

27

28 According to the recalibrational theory of anger (Sell et al., 2009), the human psychological
29 program that generates anger evolved to incentivize others to recalibrate upwards their
30 valuation of the angry individual's welfare. Ancestral individuals used anger to convince
31 others to treat them better, and the more power they had to harm and/or benefit others, the
32 more convincing they would have been in this regard: "anger is more likely to be triggered
33 when an actor is positioned to make the price of resisting recalibration high. This price is
34 higher when the actor's formidability (ability to inflict costs on the target) or the actor's
35 ability to confer/withhold benefits is greater" (Sell et al., 2009: 15074).

36 The recalibrational theory predicts that certain traits would have been particularly
37 important influences in ancestral environments on an individual's ability to impose costs or
38 confer benefits. One of these influences, aggressive formidability, would have enhanced the
39 ability to inflict costs. Because selection for traits promoting success in physical conflict is
40 stronger in males than in females (Trivers, 1972), traits that enhance aggressive formidability
41 (e.g., upper body muscle mass) should be more important as aspects of cost-imposition ability
42 in males than in females. Another important influence on one's ability to impose costs/confer
43 benefits is physical attractiveness, which, as an indicator of health and mate value in both
44 sexes, would have enhanced the ability to confer benefits as an ally or mate. Attractiveness
45 would have probably been a more significant aspect of benefit-conferral ability in females
46 than in males, because it is relatively more important in females as an index of both fertility
47 and mate value (Grammer et al., 2003). It should also be noted that some traits may enhance
48 abilities to both inflict costs and confer benefits. For example, although Sell et al. focus on
49 how strength could be used to impose costs, strength could also be used to provide benefits
50 such as protection from crime (Snyder et al., 2011). Further, moderately high male upper

51 body muscularity is itself perceived as attractive by females (Frederick & Haselton, 2007),
52 which may help explain why men who are more muscular report having had more sex
53 partners (Frederick & Haselton, 2007; Lassek & Gaulin, 2009).

54 Support for the predictions of the recalibrational theory is provided by Sell et al.
55 (2009), who found significant positive correlations in males, but not in females, between
56 upper body strength and the likelihoods of getting angry, of getting into physical fights, of
57 believing in the utility of personal and political aggression, and of succeeding in conflict. (A
58 related finding is that women perceive men with more muscular bodies as being more
59 “volatile” [Frederick & Haselton, 2007]). Sell et al. also found significant positive
60 correlations in females between self-perceived physical attractiveness and all of these anger
61 measures, with the exception of likelihood of getting into physical fights. The correlations
62 between attractiveness and anger measures were weaker in males, and most of these zero-
63 order correlations became marginal or non-significant after controlling for the effects of
64 strength.

65 Previous research suggests, then, that there are significant sex differences in the traits
66 associated with anger-related outcome variables: upper body strength is important in males
67 but unimportant in females, whereas self-assessed physical attractiveness is relatively more
68 important in females than in males. The main purpose of the current study was to test these
69 predictions using predictor variables that were based on anthropometric data, as opposed to
70 the kinds of data (mainly strength tests and self-report) collected in prior research. Sell et al.
71 (2009) assessed male aggressive formidability via several measures of strength: weight-lifting
72 ability, self-perceived strength, strength as perceived by others, flexed bicep circumference,
73 and strength scores as recorded by a hand dynamometer. Their only anthropometric measure,
74 flexed bicep circumference, was included as one item in a four-item composite variable, so

75 they did not investigate the extent to which male anger measures could be predicted based on
76 anthropometric variables alone, which is an issue that we examined in depth.
77 Further, Sell et al. used a measure of attractiveness that was based on self-report data, rather
78 than on any anthropometric data that would be informative about bodily attractiveness.
79 Because they did not collect this kind of anthropometric data, they could not test the
80 hypotheses that females with more attractive bodies (as assessed anthropometrically) tend to
81 use anger more, and that self-perceived attractiveness accurately reflects anthropometrically-
82 measured attractiveness. Both of these hypotheses are relevant to the recalibrational theory,
83 because this theory assumes that attractive people (especially, females) have greater power to
84 confer benefits because other people think they are attractive. While Sell et al. are correct
85 that human ancestors needed to perceive their own attractiveness in order to assess the extent
86 to which they could leverage it to their own advantage, it is also true that their perceptions
87 needed to have been rooted in reality in order to be used adaptively (otherwise, they would
88 have miscalculated the actual extent of their benefit-conferral advantage, and would thus
89 have used anger either less or more frequently than would have been optimal for them).
90 However, good evidence for a positive relationship between anthropometrically-measured
91 attractiveness and female anger levels has apparently not yet been produced, and some
92 evidence suggests that there is no relationship between self-perceived attractiveness and
93 anthropometric attractiveness in females (Brewer et al., 2007). We tested for both of these
94 types of relationships.

95 We used two kinds of variables as indicators of male formidability. First, as
96 explained above, we predicted that measures of upper-body muscularity such as chest,
97 shoulder and bicep circumference would correlate positively with anger use in males.
98 Second, we expected leg-body ratio (LBR) to correlate negatively with anger use in males.
99 LBR appears to correlate inversely with male fighting ability in a variety of primate species,

100 perhaps because males with lower LBR are harder to knock down (Carrier, 2006), and/or
101 because as a sexually dimorphic trait (Brown et al., 2008), LBR is associated with other
102 testosterone-dependent traits that influence formidability.

103 We used a variety of variables as indicators of female attractiveness. First, we
104 predicted that LBR would relate positively to anger in females: LBR appears to be associated
105 positively with body-shape femininity and attractiveness in females (Brown et al., 2008;
106 Rilling et al., 2009; Swami et al., 2006), although some research suggests that a moderate
107 LBR is most attractive in females (Frederick et al., 2010; Swami et al., 2007). Second, a
108 lower female waist-hip ratio (WHR) is regarded as more attractive by males in a wide variety
109 of cultures (Singh, 1993, 2002), so we expected WHR to relate negatively to anger in
110 females. (However, some evidence suggests cross-cultural variation in WHR preferences; for
111 reviews see Sugiyama [2005] and Swami & Salem [2011]). Third, waist circumference was
112 found by Rilling et al. (2009) to be a particularly significant inverse correlate of female
113 attractiveness, so we predicted it would relate negatively to female anger. Fourth and fifth,
114 we predicted that body mass index (BMI) and volume height index (VHI) would relate
115 negatively to female anger: Tovee et al. (2002) emphasized the importance of BMI as a
116 predictor of female attractiveness, while Fan et al. (2004) found VHI to be a better predictor.
117 Sixth, we predicted that bust-underbust ratio (BUR) would relate positively to female
118 attractiveness, based on work by Brown et al. (2008) which identified this relationship.
119 Finally, because a more sex-typical (i.e., feminine) female body shape is regarded as more
120 attractive (Brown et al., 2008), we derived a measure of overall “body shape femininity”
121 using principal component analysis and predicted that it would associate positively with
122 female anger.

123 Our collection of anthropometric data was aided through use of a three dimensional
124 body scanner, which uses white-light to generate a point cloud display of the body, which it

125 can then use to extract hundreds of accurate measurements. According to the manufacturer,
126 the scanner's point accuracy is < 1 mm, and its circumferential accuracy is < 3 mm (TC²,
127 2010).

128

129 **2. Method**

130

131 *2.1. Participants and procedure*

132 One-hundred and eighteen participants (56 males, 62 females, mean age 21.95 ± 4.53
133 years), mostly undergraduates at an English University, participated in exchange for
134 participation pool credit and/or a copy of their 3D body scan (for reasons discussed below,
135 this sample size was ultimately reduced to 91). After completing the questionnaire portion of
136 the study, participants' height to top of head and weight were recorded by stadiometer and
137 digital scale. Using methods similar to those used by Brown et al. (2008), participants were
138 then body-scanned with an NX12 scanner, manufactured by TC² (Cary, North Carolina,
139 USA). During the scan, participants wore scanner-appropriate clothing (tight-fitting briefs
140 and for females, a sports bra), and stood erect in a standardized pose, without flexing any
141 muscles, with arms straightened and held slightly away from the sides of the body. Two
142 high-quality scans were obtained from each participant, and the 23 trait measurements used in
143 this study were extracted from each scan. The two measurements of each trait were first used
144 to assess repeatabilities, and were then averaged to produce the single measurement used to
145 generate predictor variables. Complete scans were obtained for all participants, with the
146 exception of two very dark-skinned males whose scans were incomplete below the elbow (the
147 NX12 sometimes has difficulty scanning very dark skin). These participants were excluded
148 from analyses that required the missing data.

149

150 2.2. Predictor variables

151 With the exception of height and weight (described above), all other anthropometric
152 measurements were extracted, in centimeters, by the NX12 scanner. The following
153 measurements were used to assess upper body muscularity: horizontal shoulder
154 circumference, left and right vertical shoulder circumference (measured from the underarm to
155 the top of the shoulder), chest circumference, left and right bicep circumference, left and right
156 elbow circumference, left and right forearm circumference, and left and right wrist
157 circumference. In order to produce a general measure of upper body muscularity, we created
158 a composite measure out of the most important components of upper body muscle mass: we
159 summed the *z*-scores of horizontal shoulder circumference, chest circumference, and mean
160 bicep circumference, and called it “upper body size”. In addition, so that we could compare
161 the effects of upper and lower body muscularity, we extracted measurements of left and right
162 thigh circumference and left and right calf circumference. To measure waist circumference,
163 we took the minimum circumference between the lower ribs and top of pelvis, and to measure
164 hip circumference we took the widest circumference between crotch and waist. We
165 determined WHR by dividing waist circumference by hip circumference. We calculated BMI
166 by dividing weight in kilograms by the square of height (to top of head) in meters, and VHI
167 by dividing body volume by the square of height (to top of head) in meters. To calculate
168 BUR, we divided bust circumference by underbust circumference. Finally, to determine LBR,
169 we measured circumference at the base of the lower torso, passing through the small of the
170 lower back, and divided the frontal height of this circumference by height (to top of head).
171 Repeatabilities (intraclass correlation coefficients) for all trait measurements extracted by the
172 NX12 were high, ranging from .893 to .999.

173 To create the overall body shape femininity variable, our technique was similar to that
174 described in Brown et al. (2008). First, independent *t*-tests were conducted on a variety of

175 traits known to be sexually dimorphic, in order to see which traits would be associated with
176 the greatest between-sex variation. The four traits which generated the largest t values were
177 WHR ($t = 11.44$), horizontal shoulder circumference ($t = 10.97$), BUR ($t = -9.63$), and LBR
178 ($t = -9.14$). Next, a principal component analysis on these four traits produced one
179 component with an eigenvalue of 2.56 (the only eigenvalue greater than 1.00), which
180 accounted for 63.98% of the total variance. Variable loadings (WHR = .89, horizontal
181 shoulder circumference = .81, BUR = -.74, LBR = -.76) indicated that this component
182 captured body shape sex typicality such that higher values indicated a more masculine shape,
183 and lower values indicated a more feminine shape. We reverse coded this component so that
184 we could label it “body shape femininity”.

185 Finally, so that we could examine the relationship between bodily and self-perceived
186 attractiveness, we measured three kinds of self-perceived attractiveness via three different
187 items. With two of these items, male and female participants responded on a nine-point scale
188 ranging from “Very unattractive” to “Very attractive” to the following items: “Please tick the
189 box indicating how physically attractive you think you are, in general” (“S-P attract
190 [general]”), and “Please tick the box indicating how physically attractive you think your body
191 is” (“S-P attract [body]”). All participants provided responses to both of these items, with the
192 exception of three males who responded to neither. The third item, administered to female
193 participants only, was the measure of self-perceived attractiveness used by Sell et al. (2009):
194 “Please fill in the blank: ‘I am more attractive than _____% of other women’” (“S-P attract
195 [percentile]”).

196

197 *2.3. Outcome variables*

198 Our three anger-related outcome variables were composed of items used in the
199 original measures designed by Sell et al. (2009). Participants responded to all items on a 9-

200 point scale from “Strongly disagree” to “Strongly agree”. First, our “proneness to anger”
201 measure, which assesses one’s general likelihood to become angry in everyday life, was the
202 mean response to items 3, 6, 7, 12, 15, 18 and 21 of the original measure (Cronbach’s $\alpha =$
203 .75). Sample items are “People often irritate me” and “It is harder to get me angry than other
204 people” (reverse-coded). Second, our “history of fighting” measure, which indicates one’s
205 past frequency of engagement in physical conflict, was the mean response to all five items of
206 the original measure (Cronbach’s $\alpha = .83$). Sample items are “I have physically intimidated
207 someone who had it coming” and “I have physically defended myself against attack”.
208 Finally, our “utility of political aggression” measure was the mean response to items 8, 9, 11,
209 12 and 14 of the original measure (Cronbach’s $\alpha = .74$). Sample items are “To deter
210 violence, a country needs a strong military” and “When it comes to international conflicts,
211 violence never solves anything” (reverse-coded). One male participant failed to respond to
212 most of the history of fighting and utility of political aggression items and so could not be
213 included in analyses involving these variables.

214

215 **3. Results**

216

217 *3.1. Exclusion of older participants*

218 The initial analysis indicated that while few of the kinds of effects reported by Sell et
219 al. (2009) could be observed when analyzing the entire 118-participant sample, many of them
220 could be observed among the undergraduate-aged participants only. The age structure of our
221 sample differed from that of the samples used by Sell et al., in that we had a larger percentage
222 of participants who were older than undergraduate age, which gave our sample a higher age
223 mean and standard deviation. The age means and standard deviations of the samples used by
224 Sell et al. were 21.13 ± 2.38 (males, sample one), 19.94 ± 1.97 (males, sample two) and 18.99

225 ± 1.24 (females, sample two) (A. Sell, personal communication, May 25, 2010). Figures for
226 our original sample were 21.95 ± 4.53 , but by excluding all participants who were older than
227 the typical undergraduate age range of 18-23 years, we reduced these figures to 19.93 ± 1.44 ,
228 which were more in line with the Sell et al. samples. Excluding the 27 participants who were
229 older than 23 years reduced our sample size to 91 (51 females, 40 males). The below
230 analysis was conducted on this undergraduate-aged subsample only.

231

232 3.2. *Formidability–anger correlations*

233 Table 1 presents descriptive statistics for all study variables, separately by sex, as well
234 as the results of *t*-tests that reveal whether each trait displayed significant sexual dimorphism.
235 Table 2 presents the sex-specific correlations between each predictor variable and each
236 outcome variable. Results in Table 2 show that as predicted, measures of upper body
237 muscularity correlated significantly positively with proneness to anger and political
238 aggression in males. Four distinct upper body traits (not including the composite variable,
239 upper body size) correlated significantly positively with both of these anger variables in
240 males: horizontal shoulder circumference, mean vertical shoulder circumference, chest
241 circumference, and mean bicep circumference. Overall, the anger measure that correlated
242 most strongly positively with the upper body muscularity measures was proneness to anger.
243 Surprisingly, none of these upper body muscularity measures correlated significantly
244 positively with history of fighting, although most of these correlations were positive and
245 several approached significance. As expected, no significant correlations occurred between
246 upper body muscularity measures and anger measures among females. Also as expected,
247 lower body muscularity measures were relatively weak predictors of anger measures in
248 males, compared to upper body muscularity measures: the only significant positive

249 correlation between a lower body muscularity trait and an anger measure was between mean
250 calf circumference and political aggression in males.

251 The predicted negative correlations between LBR and anger measures in males were
252 not significant, although in the case of proneness to anger this correlation was marginally
253 significant ($p = .065$). Because LBR and upper body size were both highly correlated with
254 proneness to anger in males, but not with each other (the correlation between upper body size
255 and LBR in males was $r = -.14, p = .189$), the independent effects of these two predictors on
256 male proneness to anger were investigated via a multiple regression model. Upper body size
257 and LBR were entered together into this model with male proneness to anger as the outcome
258 variable. The overall model was significant ($R^2 = .22, p = .005$), but only upper body size (β
259 $= .40, p = .005$), and not LBR ($\beta = -.19, p = .106$), explained significant unique variance in
260 male proneness to anger.

261

262 *3.3. Attractiveness–anger correlations*

263 In females, the only significant correlations between any of the seven anthropometric
264 attractiveness measures and any of the three anger measures were between LBR and
265 proneness to anger (in the expected positive direction) and between WHR and political
266 aggression (in the expected negative direction). The only other indexes of attractiveness that
267 did correlate significantly with any anger measure in females were two non-anthropometric
268 ones, S-P attract [body], which correlated significantly positively with political aggression,
269 and S-P attract [percentile], which correlated significantly positively with both proneness to
270 anger and political aggression.

271

272 *3.4. Correlations between self-perceived and anthropometric attractiveness*

273 The three self-perceived attractiveness measures varied in the extent to which they
274 related to the female anthropometric attractiveness measures. As Table 3 shows, while S-P
275 attract [general] and S-P attract [percentile] correlated significantly in the expected direction
276 with only one of the seven anthropometric attractiveness measures (body shape femininity),
277 S-P attract [body] performed relatively well, correlating significantly in the expected
278 direction with six of these seven measures.

279 The one anthropometric attractiveness measure which failed to correlate significantly
280 in the expected direction with any self-perceived attractiveness measure in females was LBR.
281 Although the one-tailed correlations between LBR and S-P attract [body] were significant
282 among both males and females, in neither case was this correlation in the expected direction
283 or significant as a two-tailed correlation. Excessive speculation about the reasons for these
284 correlations is thus not warranted. However, we should note that in the female case, the
285 correlation is due to LBR relating positively to body fat measures (WC, WHR, BMI and
286 VHI) which themselves relate negatively to S-P attract [body].

287

288 **4. Discussion**

289

290 Two types of predictions of the recalibrational theory of anger (Sell et al., 2009) were
291 supported in the current study. First, we found that indicators of aggressive formidability
292 were significantly positively related to proneness to anger and political aggression in males.
293 While Sell et al. used predictors based mainly on upper body strength to reveal these
294 relationships, we used only anthropometric predictors (especially measures of upper body
295 muscularity). Second, we replicated the findings that among females, self-perceived physical
296 attractiveness is significantly positively correlated with proneness to anger and political
297 aggression. We did not find indicators of aggressive formidability to be significantly

298 positively correlated with history of fighting in males, but some of these correlations were
299 close to significantly positive.

300 Other findings from our study suggest that the predictions of the recalibrational theory
301 should be accompanied by some important caveats. First, most of our significant results were
302 significant only among the younger participants in our sample. This was especially true with
303 the correlations between muscularity and anger usage in males. Among the 40 males that
304 were included in the younger subsample (i.e., the male participants analyzed in the above
305 results section), there were a total of 12 significantly positive correlations found between the
306 eight upper body muscularity traits and the three anger measures (Table 2), but when the full
307 56-male sample was analyzed, only two such correlations were found. The correlations
308 between self-perceived attractiveness and anger measures in females held up comparatively
309 well in the full sample: of the three positive correlations between the self-perceived
310 attractiveness and anger measures that were significant among the 51 females in the younger
311 subsample, two were also significant in the full 62-female sample (the exception was the
312 correlation between S-P attract [percentile] and proneness to anger).

313 Our lack of full-sample results does not contrast with any findings from Sell et al.,
314 because our younger subsample was more closely matched, compared to our full sample,
315 with their samples. However, this lack does suggest that the predictions of the recalibrational
316 theory – especially, that of a positive relationship between aggressive formidability and anger
317 in males – might apply best to populations of undergraduate age. Male aggression tends to
318 peak around the undergraduate-age years and to decline thereafter (Daly & Wilson, 1988),
319 and in our full male sample ($n = 56$), age was significantly negatively correlated with political
320 aggression ($r = -.30, p = .014$), and nearly so with proneness to anger and history of fighting
321 (both r 's = $-.21$, both p 's = $.06$). It may be that as anger levels fade with age, so does the
322 relationship between muscularity and anger. Testosterone levels probably affect some of this

323 study's most important sexually dimorphic variables (e.g., muscularity, proneness to anger),
324 and as age advances further past the pubertal stages when most sexual differentiation occurs,
325 associations between these variables may weaken. Further, as males age beyond their
326 undergraduate years, their formidability may become more dependent on social power and
327 achievement (e.g., on having a high income or an influential role in their organization) as
328 opposed to physique and strength, which may also contribute to the weakening of the
329 muscularity-anger correlation.

330 The second caveat is that although the recalibrational theory predicts a positive
331 correlation between female attractiveness and anger usage, this prediction may not be
332 accurate if attractiveness is assessed in terms of standard anthropometric measures of bodily
333 attractiveness. Of the seven such anthropometric predictors that we looked at, leg-body ratio
334 and waist-hip ratio were the only two that correlated significantly with any of the three anger
335 measures in females, and each predictor did so with only one anger measure. The
336 recalibrational theory does predict that the effect of 'objective' (other-perceived)
337 attractiveness on anger usage will be mediated by self-perceived attractiveness, so perhaps
338 anthropometric attractiveness influences anger only indirectly. This argument receives some
339 support from the fact that some self-perceived attractiveness measures correlated significantly
340 positively both with some anger measures, and with some anthropometric attractiveness
341 measures, in females. On the other hand, the self-perceived attractiveness measure that best
342 predicted female anger, S-P attract [percentile] – which was also the self-perceived
343 attractiveness measure used in Sell et al. (2009) – correlated significantly with only one of the
344 seven anthropometric predictors of attractiveness (body shape femininity). Another self-
345 perceived attractiveness measure, S-P attract [body], performed much better as a predictor of
346 anthropometric attractiveness by correlating significantly in the expected direction with six of

347 the seven anthropometric predictors; however, it performed worse than S-P attract
348 [percentile] as a predictor of female anger usage.

349 The lack of strong correlations between anthropometric attractiveness measures and
350 female anger measures, and the lack of strong evidence that the measures of self-perceived
351 attractiveness that best predict anthropometric attractiveness are the same ones that best
352 predict female anger usage, raise a question: if females modulate their anger usage based on
353 their self-perceived attractiveness, then what information are they using to assess their own
354 attractiveness? Perhaps their assessments are based on facial attractiveness, which is an
355 important element of overall physical attractiveness that the current study did not measure.
356 However, it is possible that anger is modulated based on self-perceived attractiveness
357 assessments that are largely inaccurate. Previous research suggests that people are poor to
358 moderately good assessors of their own attractiveness (Brewer et al., 2007; Marcus & Miller,
359 2003; Mulford et al., 1998). In a study that was relatively similar to the current one in terms
360 of variables examined, females' self-perceived attractiveness ratings did not correlate
361 significantly with anthropometric measures of their bodily attractiveness (WHR, BMI) or
362 with other people's ratings of their facial attractiveness (Brewer et al., 2007). The authors of
363 that study explained this inaccuracy by noting that their female participants, particularly the
364 most attractive ones, tended to overestimate their own attractiveness, perhaps as the result of
365 adaptive self-deception (Trivers, 1999). However it is not clear that female participants in the
366 current study were overestimating their own physical attractiveness; in fact, as our average
367 female participant stated that she was more attractive than only about 41% of other women
368 (i.e., the mean of S-P attract [percentile] was 41.39), it is plausible that they tended to err on
369 the side of humility. Moreover, we found that when female participants were asked
370 specifically about their self-perceived bodily attractiveness (S-P attract [body]), their
371 perceptions became reasonably accurate (although as noted, S-P attract [body] was not the

372 self-perceived attractiveness measure that best predicted female anger usage). The lack of
373 relationships in females between anthropometric attractiveness measures and anger, and
374 between anthropometric attractiveness measures and the self-perceived attractiveness
375 measures that best predict anger, are puzzles meriting further investigation.

376 In addition to these caveats, some study limitations bear mentioning. First, we (like
377 Sell et al.) have been interpreting correlations between formidability and anger as evidence
378 that formidability causes anger. However, anger could also lead to formidability, if anger-
379 prone men spent more time working out in the gym. Either of these causal relationships
380 would be consistent with the correlations we found, and if both existed, there could be a
381 recursive relationship between formidability and anger: as anger-prone people became
382 stronger, they would become even more anger-prone. A second limitation is that our sample
383 size was relatively small, due both to time constraints imposed by our use of the body
384 scanner, and to our reliance on an age-restricted subsample. With a larger sample, some
385 observed non-significant relationships (such as those between history of fighting and
386 muscularity in males) would likely have been significant.

387 In conclusion, our results provide support for the recalibrational theory's predictions
388 that aggressive formidability will correlate positively with male anger usage, and that self-
389 perceived attractiveness will correlate positively with female anger usage, with the caveat
390 that these correlations may be stronger in populations of undergraduate age. Further, our
391 results suggest that the relationship between aggressive formidability and anger in males can
392 be observed even when formidability is assessed only via anthropometric measurements. Our
393 results also suggest that while anger usage correlates positively with female self-perceived
394 attractiveness, it in general does not do so with relatively objective measures of female bodily
395 attractiveness. While females may be basing their anger usage on their perceptions of their

396 own attractiveness, their perceptions do not seem to be related in a straightforward way to
397 information about their attractiveness as assessed anthropometrically.

398

399 **Acknowledgements**

400 We gratefully acknowledge the contributions of Orsolya Zsofia Bote and three anonymous
401 reviewers.

402

403 **References**

404

405 Brewer, G., Archer, J. & Manning, J. (2007). Physical attractiveness: The objective ornament
406 and subjective self-ratings. *Journal of Evolutionary Psychology*, *5*, 29–38.

407 Brown, W.M., Price, M.E., Kang, J., Pound, N., Zhao, Y., & Yu, H. (2008). Fluctuating
408 asymmetry and preferences for sex-typical bodily characteristics. *Proceedings of the*
409 *National Academy of Sciences, USA*, *105*, 12938–12943.

410 Carrier, D. R. (2006). The short legs of great apes: Evidence for aggressive behavior in
411 australopiths. *Evolution (Lawrence, Kans)*, *61*, 596–605.

412 Daly, M. & Wilson, M. (1988). *Homicide*. Hawthorne, NY: Aldine de Gruyter.

413 Fan, J., Liu, F. Wu, J. & Dai, W. (2004). Visual perception of female physical attractiveness.
414 *Proceedings of the Royal Society B: Biological Sciences*, *271*, 347–352.

415 Frederick, D. A. & Haselton, M. G. (2007). Why is muscularity sexy? Tests of the fitness
416 indicator hypothesis. *Personality and Social Psychology Bulletin*, *33*, 1167-1183.

417 Frederick, D. A., Hadji-Michael, M., Funham, A., & Swami, V. (2010). The influence of leg-
418 to-body ratio (LBR) on judgments of female physical attractiveness: Assessments of
419 computer-generated images varying in LBR. *Body Image*, *7*, 51-55.

420 Grammer, K., Fink, B., Møller, A.P., & Thornhill, R. (2003). Darwinian aesthetics: Sexual

- 421 selection and the biology of beauty. *Biological Reviews*, 78, 385–407.
- 422 Lassek, W. D., & Gaulin, S. J. C. (2009). Costs and benefits of fat-free muscle mass in men:
423 Relationship to mating success, dietary requirements and native immunity. *Evolution*
424 *and Human Behavior*, 30, 322–328.
- 425 Marcus, D. K. & Miller, R. S. (2003). Sex differences in judgments of physical
426 attractiveness: A social relations analysis. *Personality and Social Psychology Bulletin*,
427 29, 325–335.
- 428 Mulford, M., Orbell, J., Shatto, C., & Stockard, J. (1998). Physical attractiveness,
429 opportunity, and success in everyday exchange. *American Journal of Sociology*, 103,
430 1565-1592.
- 431 Rilling, J. K., Kaufman, T. L., Smith, E. O., Patel, R., & Worthman, C. M. (2009).
432 Abdominal depth and waist circumference as influential determinants of human
433 female attractiveness. *Evolution and Human Behavior*, 30, 21-31.
- 434 Sell, A., Tooby, J., & Cosmides, L. (2009). Formidability and the logic of human anger.
435 *Proceedings of the National Academy of Sciences, USA*, 106, 15073-15078.
- 436 Singh, D. (1993). Adaptive significance of female physical attractiveness: Role of waist-to-
437 hip ratio. *Journal of Personality and Social Psychology*, 65, 292–307.
- 438 Singh, D. (2002). Female mate value at a glance: Relationship of waist to hip ratio to health,
439 fecundity and attractiveness. *Neuroendocrinology Letters*, 23(Suppl 4), 81–91.
- 440 Snyder, J. K., Fessler, D. M. T., Tiokhin, L., Frederick, D. A., Lee, S. W. & Navarrete, C. D.
441 (2011). Trade-offs in a dangerous world: women's fear of crime predicts preferences
442 for aggressive and formidable mates. *Evolution and Human Behavior*, 32, 127-137.
- 443 Sugiyama, L. S. (2005). Physical attractiveness in adaptationist perspective. In D. M. Buss
444 (Ed.), *The handbook of evolutionary psychology* (pp. 293-343). New York: John
445 Wiley & Sons, Ltd.

- 446 Swami, V., Einon, D., & Furnham, A. (2006). An investigation of the leg-to-body ratio as a
447 human aesthetic criterion. *Body Image*, 3, 317–323.
- 448 Swami, V., Einon, D., & Furnham, A. (2007). Cultural significance of leg-to-body ratio
449 preferences? Evidence from Britain and rural Malaysia. *Asian Journal of Social*
450 *Psychology*, 10, 265–269.
- 451 Swami, V. & Salem, N. (2011). The evolutionary psychology of human beauty. In V. Swami
452 (Ed.), *Evolutionary psychology: A critical introduction* (pp. 131-181). West Sussex:
453 Wiley/BPS Blackwell
- 454 TC² (2010). Information about scanner accuracy downloaded from
455 http://www.tc2.com/index_3dbodyscan.html on 24 November 2010.
- 456 Tovee, M. J., Hancock, P. J. B., Mahmoodi, S., Singleton, B. R. R., & Cornelissen, P. L.
457 (2002). Human female attractiveness: Waveform analysis of body shape. *Proceedings*
458 *of the Royal Society B: Biological Sciences*, 266, 2205–2213.
- 459 Trivers, R.L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual*
460 *selection and the descent of man, 1871-1971* (pp. 136-179). Chicago, IL: Aldine.
- 461 Trivers, R.L. (1999). The elements of a scientific theory of self-deception. *New York*
462 *Academy of Sciences*, 187, 111–126.

Table 1

Descriptive statistics of all study variables, with results of t-tests for sex differences

Variable	Males			Females			Sex difference	
	<i>n</i>	Mean	S.D.	<i>n</i>	Mean	S.D.	<i>t</i>	<i>p</i>
Horiz. shoulder circ. (cm)	40	111.98	4.83	51	101.41	5.31	9.81	< .001
Vert. shoulder circ. (cm)	40	44.20	2.35	51	39.57	3.59	7.05	< .001
Chest circumference (cm)	40	101.61	6.08	51	91.65	6.58	7.42	< .001
Bicep circumference (cm)	40	30.44	2.63	51	27.75	3.36	4.15	< .001
Elbow circumference (cm)	39	26.48	1.43	51	24.54	2.21	4.79	< .001
Forearm circ. (cm)	39	27.06	1.59	51	24.68	2.01	6.06	< .001
Wrist circumference (cm)	39	17.84	0.82	51	16.86	0.81	5.70	< .001
Upper body size	40	1.63	2.05	51	-1.80	2.38	7.23	< .001
Thigh circumference (cm)	40	54.84	4.10	51	57.10	6.65	-1.89	.063
Calf circumference (cm)	40	36.50	2.35	51	35.45	3.35	1.69	.096
Leg to body ratio	40	0.58	0.03	51	0.62	0.02	-7.65	< .001
Waist circumference (cm)	40	78.88	7.12	51	71.93	8.18	4.25	< .001
Waist to hip ratio	40	0.80	0.04	51	0.71	0.05	9.77	< .001
Body mass index	40	22.86	2.59	51	22.29	3.60	0.85	.400
Volume-height index	40	20.63	2.61	51	20.51	3.37	0.19	.852
Bust to underbust ratio	40	1.11	0.03	51	1.19	0.07	-7.47	< .001
Body shape femininity	40	-0.83	0.55	51	0.83	0.44	-16.12	< .001
S-P attract [general]	38	6.08	0.91	51	5.92	1.02	0.75	.453
S-P attract [body]	38	5.87	1.34	51	5.43	1.60	1.36	.176
S-P attract [percentile]	—	—	—	51	41.39	15.90	—	—
Proneness to anger	40	5.29	1.19	51	5.27	1.33	0.06	.951
History of fighting	39	4.96	2.26	51	3.60	1.92	3.10	.003
Political aggression	39	4.15	1.54	51	3.25	1.28	3.04	.003

Note. Results are for the university-aged subsample only (ages 18-23). Values of *p* are two-tailed. For bilateral traits the mean of left-right measurements are presented.

Table 2

Correlations between predictors and anger measures

Trait	Proneness to anger		History of fighting		Political aggression	
	Male <i>r</i>	Female <i>r</i>	Male <i>r</i>	Female <i>r</i>	Male <i>r</i>	Female <i>r</i>
Horizontal shoulder circ.	.41**	.01	.24	.09	.31*	-.18
Vertical shoulder circ.	.35*	.03	.22	.08	.28*	.01
Chest circumference	.42**	-.06	.18	.20	.32*	-.14
Bicep circumference	.39**	.04	.21	.23	.34*	-.12
Elbow circumference	.43**	.01	.06	.12	.15	-.08
Forearm circumference	.37**	.02	.09	.16	.21	-.08
Wrist circumference	.26	-.07	-.03	.11	.04	-.15
Upper body size	.43**	< -.01	.22	.19	.34*	-.15
Thigh circumference	.11	-.04	.16	.14	.23	-.15
Calf circumference	.05	-.08	-.02	.14	.27*	-.15
Leg to body ratio	-.24	.31*	-.13	.19	-.04	-.13
Waist circumference	.20	.03	-.08	.05	.23	-.22
Waist to hip ratio	.13	.18	-.21	.05	.13	-.28*
Body mass index	.21	-.02	-.02	.13	.26	-.16
Volume-height index	.31*	< -.01	.07	.14	.24	-.18
Bust to underbust ratio	-.01	-.02	.27*	-.02	.05	-.01
Body shape femininity	-.33*	.02	< -.01	-.01	-.18	.19
S-P attract [general]	.22	.20	.05	-.09	.03	.11
S-P attract [body]	.19	.08	.19	-.18	.10	.27*
S-P attract [percentile]	—	.26*	—	-.12	—	.29*

Note. Results are for the university-aged subsample only (ages 18-23, 40 males, 51 females). Values of *p* are one-tailed. For bilateral traits the mean of left-right measurements are presented.

p* < .05, *p* < .01.

Table 3

Intercorrelations between attractiveness measures

Measure	1	2	3	4	5	6	7	8	9
1. LBR	—	-.32*	-.26	-.41**	-.24	.18	.67***	.08	.30*
2. WC	.41**	—	.84***	.83***	.88***	-.34*	-.78***	-.06	-.16
3. WHR	.28*	.75***	—	.66***	.62***	-.50**	-.79***	.05	-.02
4. BMI	.34**	.89***	.55***	—	.84***	-.37*	-.80***	-.05	-.11
5. VHI	.37**	.90***	.56***	.98***	—	-.18	-.66***	-.15	-.18
6. BUR	.12	.22	.05	.36**	.28*	—	.56***	-.14	-.13
7. BSF	.15	-.51***	-.65***	-.31*	-.35**	.54***	—	-.08	.04
8. S-P [g]	.03	-.10	-.10	-.12	-.14	.21	.28*	—	.74***
9. S-P [b]	-.25*	-.34**	-.45***	-.27*	-.32*	.29*	.44**	.56***	—
10. S-P [p]	.03	-.13	-.17	-.14	-.15	.12	.26*	.60***	.57***

Note. Results are for the university-aged subsample only (ages 18-23, 40 males, 51 females). Correlations for males are presented above the diagonal, and correlations for females are presented below it. Values of p are one-tailed. WC = waist circumference, BSF = body shape femininity, S-P [g] = self-perceived attractiveness [general], S-P [b] = self-perceived attractiveness [body], S-P [p] = self-perceived attractiveness [percentile].

* $p < .05$, ** $p < .01$, *** $p < .001$.