

Research



Cite this article: Sell A, Lukazsweski AW, Townsley M. 2017 Cues of upper body strength account for most of the variance in men's bodily attractiveness. *Proc. R. Soc. B* **284**: 20171819.
<http://dx.doi.org/10.1098/rsob.2017.1819>

Received: 14 August 2017

Accepted: 16 November 2017

Subject Category:

Behaviour

Subject Areas:

behaviour, cognition, evolution

Keywords:

formidability, physical strength, attractiveness, mate selection

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Electronic supplementary material is available online at <https://dx.doi.org/10.6084/m9.figshare.c.3942514>.

Cues of upper body strength account for most of the variance in men's bodily attractiveness

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Evolution equips sexually reproducing species with mate choice mechanisms that function to evaluate the reproductive consequences of mating with different individuals. Indeed, evolutionary psychologists have shown that women's mate choice mechanisms track many cues of men's genetic quality and ability to invest resources in the woman and her offspring. One variable that predicted both a man's genetic quality and his ability to invest is the man's formidability (i.e. fighting ability or resource holding power/potential). Modern women, therefore, should have mate choice mechanisms that respond to ancestral cues of a man's fighting ability. One crucial component of a man's ability to fight is his upper body strength. Here, we test how important physical strength is to men's bodily attractiveness. Three sets of photographs of men's bodies were shown to raters who estimated either their physical strength or their attractiveness. Estimates of physical strength determined over 70% of men's bodily attractiveness. Additional analyses showed that tallness and leanness were also favoured, and, along with estimates of physical strength, accounted for 80% of men's bodily attractiveness. Contrary to popular theories of men's physical attractiveness, there was no evidence of a nonlinear effect; the strongest men were the most attractive in all samples.

1. Introduction

Sexually reproducing species, such as humans, typically have evolved mechanisms that function to discriminate between potential mates. These mechanisms evolved because they focused mating effort on targets that, ancestrally, increased the probability of having multiple healthy offspring. The criteria that these evolved mechanisms use reflect the ancestral reproductive consequences of mating with different individuals. This paper focuses on mate choice mechanisms in human females, specifically the visual assessment mechanisms that appraise the male body.

Ancestral humans fit a general mammalian pattern in which the females of the species have a higher obligate parental investment in offspring [1,2]. Specifically, females contribute the larger gamete to the formation of their offspring, gestate the offspring during which the child feeds from the maternal bloodstream, and nurse the offspring to provide calories and antibodies. Even after these investments are met, female mammals continue to be the primary caretakers of their offspring and generally provide calories, protection from predators and hostile males, and sometimes transportation [3].

This recurrent pattern has led to two selection pressures highly active on mammalian females: (i) securing a mate with good genetic quality so as to package your own genes with those that will enhance the survival and reproduction of your offspring, and (ii) securing a mate who is able and willing to provide investment to you and your offspring [4–9].

(a) Securing a mate with high genetic quality

The mechanisms of diploid sexual reproduction generate offspring whose genome is a joint product of genes of both of its parents. As such, when a female reproduces

with a male, the genes that she passes onto her offspring will be bundled with the genetic code of the male for several generations to come. This bundling will slowly decompose each generation as meiosis breaks apart the gene linkages, but the selection pressure is clear and powerful. Females who reproduce with males whose genetic code generates higher quality offspring will outreproduce females who do not.

The genetic quality of a man is, in part, indicated by the quality (or condition) of his phenotype. In particular, men's bodies scale to energetic demands, enabling men with greater disease resistance to grow larger and fitter bodies [6,10–12]. This predicts that women will find physically fitter and physically stronger men more attractive [13–15].

(b) Securing resource investment

In some species, including humans, males will expend parental effort on their offspring. The ability and willingness to invest is a high value commodity for the females in those species to the extent that it is limited and uncertain. As such, selection equipped females in some species with mechanisms for assessing the ability and willingness of mates to invest [1,3,8].

Human males, compared to other mammals, are highly investing parents [10,16]. As such, one would predict that women have mechanisms for assessing a man's ability and willingness to invest resources in future offspring [8]. Because a man's access to resources depends, in part, on his ability to win conflicts of interest with other males, visually accessible cues of physical formidability should be attractive to women because stronger men would have been able to secure a greater share of resources and be better able to defend himself and those he values from exploitation [17,18]. Greater physical formidability likely promotes men's resource accrual via multiple pathways. Not only are physically strong men more likely than weaker men to prevail in direct agonistic contests over resources [17–20], but they are also better hunters [21], and perceived by others in their communities as more effective generators of collective benefits related to resource production [22], leadership [18,23,24], and coalitional defence [23]. In total, these considerations suggest that physical formidability would have been a reliable positive predictor of men's ability to accrue resources that could be invested in ancestral women and offspring.¹

It has been hypothesized that physically formidable men, although better *able* to invest resources in a family, may be less *willing* to do so than weaker men of poorer quality [7,13]. The basis for this postulate is that men with higher bargaining power on the mating market may be better able to pursue a strategy of quantity by mating with multiple females and leaving the direct provisioning of offspring to the mothers (assisted by their kin or unknowing cuckolds). Evidence supports the prediction that physically stronger men are indeed more likely to succeed in pursuing sex with multiple partners [15,20]. However, physical strength bears no relationship with men's motivation to form committed pair-bonds [15]. Moreover, within natural fertility populations, men's extra-pair affairs typically occur before their primary partner has demonstrated fertility; by the time a wife has yielded one or more dependent offspring, few husbands maintain consorts outside the pair-bond [25]. This makes functional sense given the resource-intensiveness of investment in human offspring [16]. Thus, there is reason to doubt the hypothesis that highly physically formidable men were ancestrally unwilling to invest resources in a woman and their shared offspring.

(c) Formidability and men's bodily attractiveness

Evolutionary psychologists studying women's mate choice mechanisms have argued that both of these selection pressures, securing high-quality genes and securing investment from one's mate, have been active in the hominid line [6,7,26]. Both of these potent selection pressures predict that physically stronger men should be attractive to women. Therefore, women's mate choice mechanisms should evaluate the physical attractiveness of men's bodies with a focus on features that indicate formidability (i.e. fighting ability), physical fitness, strength and general health. Indeed, research has shown that women are attracted to men with cues of physical formidability.

For example, correlates of upper body strength have been shown to be attractive in men, including having wider shoulders [27–30], being physically fit [31], and having greater handgrip strength [32,33]. Men with greater handgrip strength also self-report that they more attractive [33,34], and that they have greater mating success [14,15,20]. Furthermore, numerous researchers have documented that physically taller men are more attractive [29,35,36]. Finally, men appear to know that women find stronger men attractive; cross-cultural data show that men generally desire to have stronger bodies in order to attract women [37,38].

More directly on point with the hypotheses here, Franzoi & Herzog [39] surveyed women and asked them what features they were attracted to in men; the results showed that women particularly valued components of upper body strength, e.g. 'muscular strength', 'biceps'. Similarly, Jones and co-workers [40] showed that men whose bodies were rated as more 'masculine' were preferred to men whose bodies were rated as 'feminine', and a similar study using composite images confirmed that manipulating men's bodies to appear more masculine increased their attractiveness [41]. Similar work shows that women generally prefer figures representing mesomorphic body types (i.e. muscular bodies) [42,43]. However, based on the aforementioned hypothesis that highly formidable men are relatively unwilling to invest resources in offspring, some researchers have suggested an inverted-U effect such that women prefer moderately strong men but not very strong or weak men [13,44].

While these studies collectively show good evidence that there exist significant correlations between cues of formidability and physical attractiveness in men, the magnitude of that effect in a natural sample has not been measured and reported. In short, we do not know how much of the variance in a man's bodily attractiveness is predicted from how strong he looks. This study was designed to answer that question.

Specifically, our research questions are as follows:

- (1) How much variance in male bodily attractiveness is explained by looking strong?
- (2) Is there a linear or curvilinear relationship between physical strength and attractiveness in men? (a test of the 'inverted-U' hypothesis)
- (3) Do some significant set of women prefer physically weaker looking men?
- (4) Are there aspects of men's bodies that differentiate attractiveness and physical strength?

2. Material and methods

Two studies were run in which photographs of men's bodies were shown to a population of raters who estimated either the men's physical strength or their physical attractiveness. The

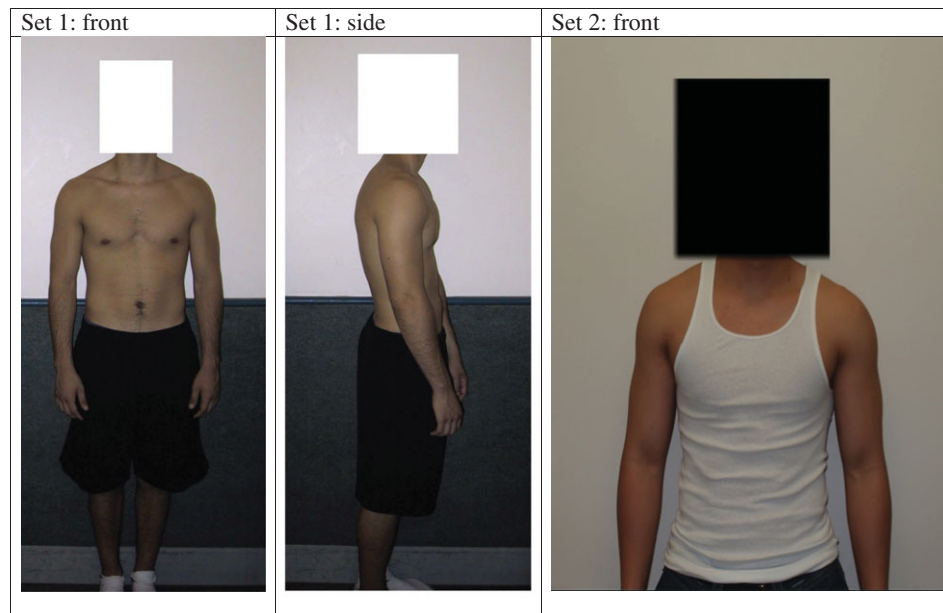


Figure 1. Example photographs from studies 1 and 2. (Online version in colour.)

men in the photographs had previously been measured on actual physical strength, height and weight.

(a) Subjects

The men whose bodies were photographed (henceforth *subjects*) were taken from two databases of young college students at US universities reported in Sell, Tooby & Cosmides [17] (herein Set 1) and Lukaszewski & Roney [33] (herein Set 2). In both sets of photographs, the subjects' faces were obscured. See figure 1 for sample photographs. Set 1 photos included both front and side views; Set 2 photos had only front views.

(b) Raters

Raters were student volunteers from Griffith University in Australia and Oklahoma State University students from the United States. Raters were given a link to an online survey (run in Qualtrics) which contained some simple demographic questions followed by static displays of the photographs of subjects. Raters were instructed to rate either 'physical attractiveness' or 'physical strength'—*between subjects*, and rated photographs only from one set, either Set 1 or Set 2. Raters who were shown photographs from Set 1 rated photographs of men from the front and side separately (i.e. a subject would see the photograph of a man from the front, and then later see that same man from the side). Set 2 photographs were taken only from the front.

Previous researchers have shown that women (and men) have assessment mechanisms that are calibrated to estimate men's formidability (i.e. fighting ability) based on visual and auditory cues that function across cultures and language groups [45–48]. We followed Sell and colleagues and had raters rate 'physical strength' from '1 = very weak' to '7 = very strong'. For attractiveness, raters rated the men from '1 = very unattractive' to '7 = very attractive'.

Both subject and rater demographics are reported in table 1. For more information on physical strength measures, see the source articles for the subjects.

3. Results

(a) Validation check: can raters accurately assess actual physical strength?

Previous research with the same photographs found that raters could accurately assess physical strength [23,47]. To replicate

this effect and validate our method, we tested whether raters' estimates of physical strength accurately tracked our objective strength ratings. We computed the average ratings of strength for each subject and correlated that rating of strength with the subject's actual objective strength as measured in the original studies (table 1). Results are reported in table 2.

Like previous research, ratings of strength were good predictors of actual strength. There was only a small difference between front and side photos for Set 1, but ratings for Set 2 were less accurate than those in Set 1. This difference is consistent with original research done on the photos and likely reflect differences in the comprehensiveness of the strength measure (a battery of upper body strength measures at the gym versus proxy measurements) and the range of the photos (full body, shirtless versus truncated body with tank top).

Previous research shows that men and women are equally accurate at assessing physical strength [46,47]. This was confirmed here. When raters were split between males and females, there were no significant or substantial differences between them; e.g. ratings of strength were equally accurate at predicting actual strength for men and women; ratings of attractiveness were also equally predictive of physical strength. In future analyses, male and female raters were always combined.

(b) Research question no. 1: how much variance in male bodily attractiveness is explained by looking strong?

To answer this question, we computed the average ratings of attractiveness and strength for each photographed subject. We then regressed the average rating for strength against the average rating for attractiveness. Scatterplots are shown in figure 2, and illustrate that most of the variance in attractiveness is accounted for by ratings of strength (R^2 varied from 0.61 for side photos of Set 1 to 0.73 for front photos of both Set 1 and Set 2).

Additionally, we consider the impact of increasing the sample of raters on the correlation between rated strength and attractiveness. To do this, we randomly select a fraction

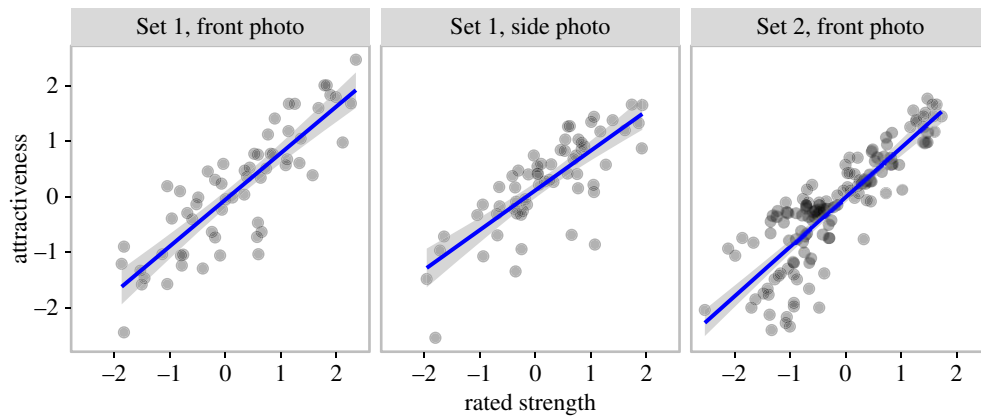


Figure 2. Ratings of strength from male bodies closely track attractiveness.

Table 1. Subject and rater demographics.

	Set 1	Set 2
subject demographics		
population	UC Santa Barbara students with gym access	UC Santa Barbara students enrolled in psychology courses
sample size, age	$n = 61$, age 21.1 (s.d. = 2.4)	$n = 131$, age 18.9 (s.d. = 1.4)
mean body measurements	height (cm): 181.2, s.d.: 8.47 weight (kg): 79.1, s.d.: 12.44 BMI: 24.0, s.d.: 2.75	height (cm): 178.3, s.d.: 7.59 weight (kg): 73.9, s.d.: 12.42 BMI: 23.2, s.d.: 4.23
strength measures	four weight-lifting machines measuring upper body strength	chest compression and grip strength
source of dataset	Sell, Tooby & Cosmides [17]	Lukaszewski & Roney [33]
photographs	full body, shirtless, standardized pants. Front and side pictures.	upper body (plus some upper leg), standardized tank top shirts. Front view pictures only.
rater demographics		
population	Griffith University and Oklahoma State University student volunteers	
sample size, age (strength raters)	$n = 151$ (113 female) mean age 21.5, s.d. = 4.96	$n = 68$ (51 female) mean age 22.0, s.d. = 5.33
sample size, age (attractive raters)	$n = 163$ (124 female) mean age 21.1, s.d. = 3.50	$n = 58$ (36 female) mean age 20.3, s.d. = 3.02

Table 2. Predicting actual strength from ratings of strength.

	actual strength		
	Set 1: front	Set 1: side	Set 2: front
strength ratings (<i>Std. Beta</i>)	0.58***	0.61***	0.45***
observations	61	61	130
R^2	0.33	0.37	0.21

* $p < 0.01$; ** $p < 0.05$; *** $p < 0.01$.

of raters and estimate the correlation between rated strength and attractiveness for that sample. We do this with increasing proportions of the sample to see how many raters are required for peak accuracy. The procedure was repeated 100 times for each sample size and then averaged to

generate a representative estimate of the relationship between attractiveness and ratings of strength (figure 3).

Results show that the relationship between attractiveness and rated strength plateaus with approximately 100 raters. Our sample sizes (table 1) are therefore appropriate, and larger sample sizes would be unlikely to yield more accurate estimates. Figure 3 also shows that samples sizes with less than 75 raters will likely underestimate the true correlation between men's bodily attractiveness and their perceived strength, which is reliably above $r = 0.80$.

(c) Research question no. 2: is there a linear or curvilinear relationship between physical strength and attractiveness in men? (A test of the 'inverted-U' hypothesis)

Frederick & Haselton [13] have argued there may be a curvilinear relationship between strength and attractiveness

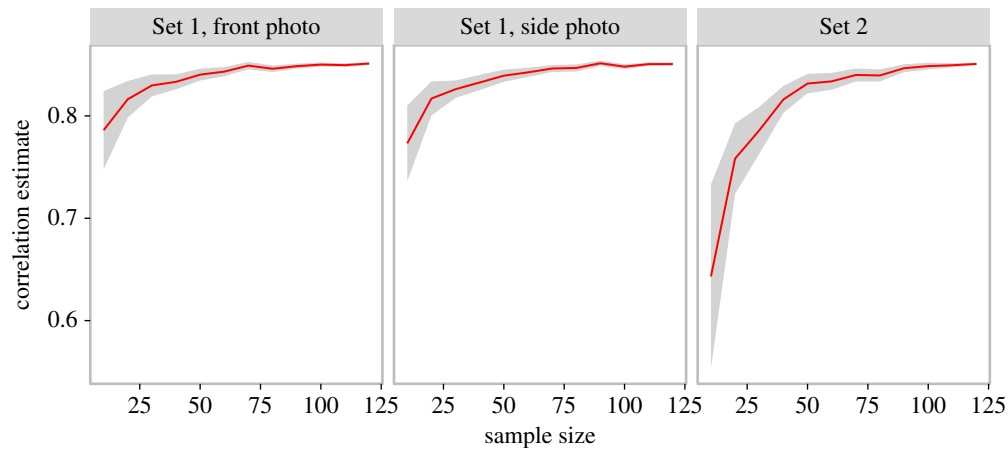


Figure 3. Estimated correlation between attractiveness and ratings of strength as sample size of raters increases.

Table 3. Results for linear and quadratic models for both sets of subjects. All coefficient estimates are standardized.

	attractiveness					
	front: Set 1		side: Set 1		front: Set 2	
	Step 1	Step 2	Step 1	Step 2	Step 1	Step 2
rated strength linear	0.853***	0.853***	0.779***	0.779***	0.852***	0.852***
rated strength quadratic	n/a	0.048	n.a.	−0.120	n.a.	0.056
adjusted R^2	0.723	0.720	0.601	0.609	0.724	0.725

* $p < 0.01$; ** $p < 0.05$; *** $p < 0.01$.

such that extremely strong men may be less attractive than moderately strong men. The scatterplots in figure 2 show no evidence of this, but a more formal test was run using two functional forms: linear (attractiveness = $f(\text{strength})$) and quadratic (attractiveness = $f(\text{strength}, \text{strength}^2)$). If there is an inverted-U shape when perceived strength maps onto attractiveness, the quadratic term should be statistically significant and the quadratic models should yield a better overall fit to the observed data. We used orthogonal polynomials to fit these models to avoid the correlation between the linear and the quadratic strength terms.

Table 3 presents the two-step models (step 1 = linear only; step 2 = linear and quadratic) for all three sets of subjects. None of the quadratic models returned a statistically significant point estimate for the quadratic strength term. For all linear models, the strength coefficient was statistically significant at $\alpha < 0.001$ level. The amount of variance explained by the quadratic term is essentially equivalent to that explained by the simpler linear model. We found no evidence of the inverted-U hypothesis; rather, in both samples, the strongest men were the most attractive, and the weakest men were the least attractive.

(d) Research question no. 3: do some significant set of women prefer physically weaker looking men?

Research on facial attractiveness reveals that some women prefer more feminized and less dominant faces—which, based on the contested idea that men of high phenotypic quality are less likely to invest in a family, has been interpreted as a preference for higher investing male partners (e.g. Little *et al.*

[49]). To the degree that facial masculinity and bodily strength indicate the same aspects of phenotypic quality, this view may predict that some women will prefer physically weaker men's bodies. To test this, we examined the data from individual female raters to see if there was a subpopulation of raters who preferred physically weaker men.

For each female rater, we computed the correlation between her ratings of the men's attractiveness and the men's *actual* physical strength (as measured in the original studies, table 1). These correlations were examined to see if any women in our samples showed a significant preference for weaker men. They did not. None of the 160 women in our study who rated attractiveness produced a statistically significant preference for weaker men (all $p > 0.05$). One woman who rated men in Set 1 showed a marginally significant preference for weak men when viewing them from the front, $r = -0.24$, $p = 0.06$, but the same woman rated those same men from the side and had a non-significant preference for *strong* men, $r = 0.10$. In other words, we could find no evidence that there exists a sizeable population of women who prefer physically weaker men when evaluating male bodies.

(e) Research question no. 4: are there aspects of men's bodies that differentiate attractiveness and physical strength?

Given the strong correlation between ratings of attractiveness and ratings of strength, it is likely that many male bodily cues underlie both ratings. Regardless, ratings of physical strength

Table 4. Predicting actual strength from attractiveness and ratings of strength.

	actual strength		
	Set 1: front	Set 1: side	Set 2: front
attractiveness (<i>Std. Beta</i>)	−0.42*	−0.21	−0.50***
strength ratings (<i>Std. Beta</i>)	0.93***	0.77***	0.88***
observations	61	61	130
R^2	0.38	0.39	0.28

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

do not fully account for male bodily attractiveness in our samples. For one, there is variance in attractiveness that is unexplained by ratings of strength, approximately 25% to 30% (though some of this will be error). Secondly, ratings of strength were better predictors of actual observed strength than were attractiveness ratings; i.e. attractiveness correlated with actual measured strength at $r = 0.38$ (Set 1: front), 0.39 (Set 1: side) and 0.25 (Set 2: front), all $p < 0.01$ (compare these numbers with those of rated strength in table 2). In other words, despite the extremely high correlation between attractiveness and ratings of strength, actual strength was still better predicted by ratings of strength rather than attractiveness. To confirm, we ran three simultaneous regression analyses predicting objectively measured strength from both attractiveness and ratings of strength. Results, shown in table 4, show that ratings of strength are superior predictors of actual strength than are ratings of attractiveness. Furthermore, for two of the three regressions, the attractiveness measure became a negative predictor once strength ratings were controlled for. In other words, there appear to be cues in the male body that accurately indicate strength (and are detected as such by raters), but nonetheless are neutral or negatively valued when assessing attractiveness.

What could these cues be? Weight and height are candidates. Weight is well correlated with physical strength in most samples, but can also be influenced by large amounts of fat storage, which is unattractive [50]. Height is less well correlated with strength, but is a persistent predictor of attractiveness [35]. Both height and weight (particularly fat storage) may be indicators of overall health, physical conditioning, and other aspects of hunting ability and endurance that women are predicted to assess during mate choice. To test whether height and weight distinguish ratings of strength from attractiveness, we ran three simultaneous linear regression analyses with subject height, weight and average rating of strength predicting their attractiveness. Results are reported in table 5 (see electronic supplementary material similar results using BMI).

Results of note include:

- (1) Ratings of strength are a robust and much larger predictor of attractiveness than either height or weight.
- (2) Height is attractive even independent of making a man look strong. Controlling for how strong a man actually looks, raters still classify taller men as more attractive in two of the three samples. Set 2 did not show evidence that raters prefer taller men (independent of the fact that height makes men look stronger), but this sample also provided fewer visual cues of height (note the ridge in

Table 5. Rated strength, height and weight predict attractiveness.

	attractiveness		
	Set 1: front	Set 1: side	Set 2: front
strength ratings (<i>Std. Beta</i>)	0.849***	0.776***	0.843***
height	0.381***	0.574***	0.023
weight	−0.345***	−0.495***	−0.315***
observations	61	61	127
adjusted R^2	0.787	0.749	0.822

* $p < 0.01$; ** $p < 0.05$; *** $p < 0.01$.

Set 1 that could be used as a cue of height, and Set 2 photos cut off above the knee).

- (3) Weight is unattractive after controlling for how strong a man looks. The zero-order correlation between weight and attractiveness is positive, but this reverses once ratings of strength are controlled for. This is consistent with the hypothesis that women's mate choice mechanisms respond to muscle mass positively but large stores of body fat negatively.
- (4) Height, weight and ratings of strength collectively account for approximately 80% of the variance in male bodily attractiveness.

4. Discussion

The results show that most male bodily attractiveness stems from cues of formidability and physical strength, and that strength increases attractiveness in a linear fashion. The rated strength of a male body accounts for a full 70% of the variance in attractiveness. Additional variance (up to 80%) can be explained by adding the premium women put on height and subtracting the penalty put on additional body mass unrelated to physical strength.

This effect of height and weight on attractiveness may be due to mate choice mechanisms responding to cues of health [50], or to the benefits that height and lean bodies have in protracted aggression, hunting and other aspects of fighting ability. Note, however, that ratings of strength themselves are known to privilege taller men and penalize obesity [47]. In other words, when rating physical strength, raters are known to treat taller men as physically stronger (independently of their actual weight-lifting strength), and yet even controlling for these ratings taller men are treated as more attractive. This suggests that women are treating lean and tall men as more attractive for reasons other than just fighting ability.

Contrary to the inverted-U hypothesis, we found no evidence that extremely strong men were less attractive. The strongest men in our sample were the most attractive (figure 2). However, there is a sizeable dataset across many cultures that does show that women did not prefer the strongest men [44]. What caused these divergent results? The most likely cause is that Frederick and colleagues used artificial depictions of human males (i.e. drawings and computer-generated images) rather than actual photos. These drawings presented males whose physical strength likely appeared beyond the normal

human maximum strength [13]. To test this explanation, one would need a wider range of muscular men.

Of course, the fact that physical strength is assessed as more attractive in virtually all our subjects is still consistent with the fact that some subjects may put a higher premium on physical strength than other subjects (i.e. strategic pluralism [7]). For example, evidence shows that women who are more afraid of crime show a stronger preference for formidable men [51]. Women who are less afraid of crime are presumably still attracted to physically strong male bodies, but they may value other characteristics more highly. Also, it is important to remember that male visual bodily attractiveness is one small aspect of overall mate value in men [5,9,52,53]. Nothing we have found contradicts the theory (and evidence) that there are ovulatory cycle effects such that women in different cycle phases may shift weightings on different preferences [54,55].

However, the data presented here are puzzling for theories that suggest that some women will prefer less formidable men. For example, data show that some women prefer less 'masculine' faces and this has been interpreted as an evolved strategy to navigate the trade-off between securing high-quality mates and leaving one vulnerable to exploitation by powerful men [49]. In other words, it would not have served a woman in past environments to prefer the strongest men because such men may be more likely to exploit them or be less interested in investing in them. This claim is a component of 'trade-off theory' which argues—consistent with much evidence—that women's mate choice mechanisms calibrate themselves in response to ecological variables that ancestrally

predicted the genetic pay-offs for those preferences [7]. However, regarding the specific claim that some women prefer less dominant, masculine or formidable males because these males are more investing; we could find no evidence that a substantial (or even insubstantial) number of women found less strong men attractive when assessing the body. Why some women prefer less dominant or less masculine faces and voices (e.g. reference [56]), and yet prefer more physically strong bodies remains to be explained (note that ratings of dominance and ratings of strength are extremely highly correlated [57]). There appears to be disunity between face and body processing such that strong bodies, but not the faces that accompany them, are seen as most attractive [40].

Ethics. Ethics approval for use of human subjects was granted by Griffith University (protocol no. 2015/599).

Data accessibility. All data are available from the Dryad Digital Repository: (<http://dx.doi.org/10.5061/dryad.h06v7>) [58].

Authors' contributions. A.S. and A.W.L. gathered data and wrote the manuscript and edited, A.S. and M.T. performed data analysis.

Competing interests. We declare we have no competing interests.

Funding. We received no funding for this study.

Endnote

¹We reiterate that this predictor is only one of many variables that women would need to assess to predict men's investment potential. Most variables—presumably—are not visually accessible at all, see references [5–9] for examples.

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