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Original Research Article

Body Symmetry and Physical Strength in Human Males

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Objectives: Body symmetry and physical strength in males have been related to aspects of mate "quality"—women seem to prefer men who display both "good genes" (as indexed by high symmetry/developmental health) and fighting ability (as indexed by physical strength). Here we show that fluctuating asymmetry (FA) of the body and physical strength are negatively correlated.

Methods: Body FA (from 12 paired traits) and handgrip strength (HGS; a measure of muscular power and force) were measured in a sample of 69 heterosexual, right-handed men (18–42 years).

Results: There were positive correlations of body symmetry with HGS after controlling for the effect of body-mass-index.

Conclusions: We conclude that in males, body symmetry and physical strength are correlated such that symmetric individuals tend to develop higher strength, which may contribute to their success in inter- and intra-sexual selection. Am. J. Hum. Biol. 26:697–700, 2014.

Bilateral symmetry of physical traits is thought to reflect an organism's ability to resist developmental perturbations and is therefore considered to be a cue to an individual's genetic quality, including health (Møller and Swaddle, 1997; Møller, 2006). However, the development and maintenance of symmetry is crucial, and there is considerable variation in individuals' asymmetry across taxa. Fluctuating asymmetry (FA), that is, subtle random deviations from perfect bilateral symmetry in traits, which are symmetrical at the population level (van Valen, 1962) occurs early in ontogeny in response to environmental and hormonal stress (Thornhill and Gangestad, 1996; Thornhill and Møller, 1997). It is known that poor environmental conditions and high levels of sex steroids can hamper immunocompetence and thus increase FA (Folstad and Karter, 1992; Manning et al., 2006; Thornhill and Møller, 1997).

Studies on animals showed that FA is associated negatively with male fighting ability and with the size of secondary sexual characteristics (Manning and Chamberlain, 1993; Møller and Pomiankowski, 1993; Thornhill, 1992). Hence, it has been proposed that in human males FA might reflect resource holding potential (RHP; Furlow et al., 1998; Muñoz-Reyes et al., 2012; Wilson and Manning, 1996) as low FA males seem to perform better in obtaining resources, especially in situations involving aggression (Manning and Wood, 1998; Zaatari and Trivers, 2007). Indeed certain physical traits, which are supposed to reflect high RHP in males, such as facial masculinity (Gangestad and Thornhill, 2003), body mass, and height (Gangestad and Thornhill, 1996; Manning, 1995) correlate negatively with FA, and recent research shows that both men and women consider these cues in their assessment of male fighting ability (Sell et al., 2009, 2012; Muñoz-Reyes et al., 2012).

Here we report data on the relationship between body FA and hand-grip strength (HGS)—a measure of overall physical strength and muscularity in human males (Mathiowetz et al., 1984; Nicolay and Walker, 2005; Rantanen et al., 2000). HGS has been shown to correlate with male physical traits such as digit ratio—a possible biomarker of prenatal androgen effects (Fink et al., 2006)—facial masculinity, dominance, and attractiveness (Fink et al., 2007) and body morphology (Gallup et al., 2007). However, the relationship of HGS and body FA, particularly that of HGS and body FA in males, has not yet been examined in detail. One study (Van Dongen and Sprengers, 2012) considered HGS and body FA in a sample of 52 males and 48 females. They reported no significant association. However, body FA was restricted to five paired traits from hands and measurement was from scans of hands. There is concern that FA's measured indirectly from scans of the hand are not strongly related to FA's from direct measurements (Manning et al., 2006). Therefore, we focused on males and considered the relationships between HGS and FA measured directly from the upper and lower body. We predicted that body FA would show negative associations with HGS, that is, males with lower FA should be physically stronger.

MATERIALS AND METHODS

We collected anthropometric measurements of 80 British males, aged 18–42 years ($M = 21.61$, $SD = 4.01$), mainly graduate and undergraduate students of Northumbria University (UK). Participants reported their age and sexual orientation and handedness. Their body height (cm) and mass (kg) were measured using an anthropometer and scales (Seca GmbH, Germany) for subsequent calculation of body-mass-index (BMI; mass/height(m)^2)—a known correlate of HGS (Chandrasekaran et al., 2010).

Measurements of left and right side 2nd to 5th finger lengths (2D to 5D), breadth of the hand, wrist, elbow,

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TABLE 1. Descriptive statistics (mean and standard deviation) of anthropometric measurements (N = 69)

	Height	Weight	BMI	Composite FA	Right HGS	Left HGS
M	176.30	77.11	24.77	0.22	38.24	35.71
SD	6.44	13.24	3.87	0.06	8.93	9.00

knee, ankle and foot, and the length and width of the ear were obtained by one investigator (B.W.) using digital calipers (Mitutoyo, Japan) and an anthropometer (Lafayette instruments, USA). Each trait was measured twice and the arithmetical mean of the two measurements was used in a composite fluctuating asymmetry (CFA) score, summarizing (unsigned) left minus right side differences of trait measurements (absolute FA = |L − R|), corrected for trait size according to |L − R|/0.5 × (R + L).

Left and right side handgrip strength were measured using a hand dynamometer (Takei Kiki Kogyo, Japan). Participants were asked to perform a maximum force trial for each hand ("Squeeze as hard as you can"). Strength measurements were collected twice and the mean of the two recordings was used in the analysis. For the final analysis, we considered only those males who claimed to be heterosexual and right-handed. The final sample size was $N = 69$. All statistical tests for significances were carried out one-tailed (alpha was set to 5%).

RESULTS

T1 Table 1 reports descriptive statistics of height, weight, BMI, CFA and HGS. One-sample Kolmogorov–Smirnov goodness of fit-tests revealed no significant deviation of height, weight, CFA, and HGS measures from normality (all $Z < 0.71$, all $P > 0.69$). First and second measurements of body traits were highly correlated with one another (all $r > 0.97$, all $P < 0.0001$) and reliability was found to be sufficiently high (all Cronbach alpha > 0.90).

Zero-order correlations (Pearson r) indicated no significant relationships of age and CFA ($r = 0.15$, $P = 0.23$) and HGS (left hand: $r = -0.10$, $P = 0.42$; right hand: $r = -0.11$, $P = 0.36$). There were negative relationships of CFA with HGS (left hand $r = -0.14$, $P = 0.12$; right hand $r = -0.23$, $P < 0.05$). Left and right HGS was highly positively correlated ($r = 0.89$, $P < 0.0001$). BMI showed significant correlations with HGS (left hand $r = 0.33$, right hand $r = 0.28$, both $P < 0.01$), and a significant positive correlation with CFA ($r = 0.25$, $P < 0.05$). Therefore, we recalculated the relationship of CFA and HGS. The latter was regressed on BMI and the residuals used as a measure of HGS independent of BMI (*res* HGS). We obtained significant negative correlations of CFA with both left and right *res* HGS (left hand $r = -0.24$, $P < 0.05$; right hand $r = -0.31$,
F1 $P < 0.01$) (Fig. 1).

An inspection of signed left–right differences in trait measurements indicated directional asymmetry (i.e., a significant deviation from the mean of zero; all skew < ±0.93, all kurtosis < ±2.59) for some of the 12 traits (2D, 3D, width of hands, wrists, elbows, knees, and feet). Excluding them from the statistical analysis resulted essentially in the same findings. CFA (5 traits) and HGS was correlated negatively (left hand $r = -.20$, $P = .054$; right hand $r = -.27$, $P < .05$), also when controlling for the effect of BMI (left hand $r = -.23$, $P < .05$; right hand $r = -.30$, $P < .01$).

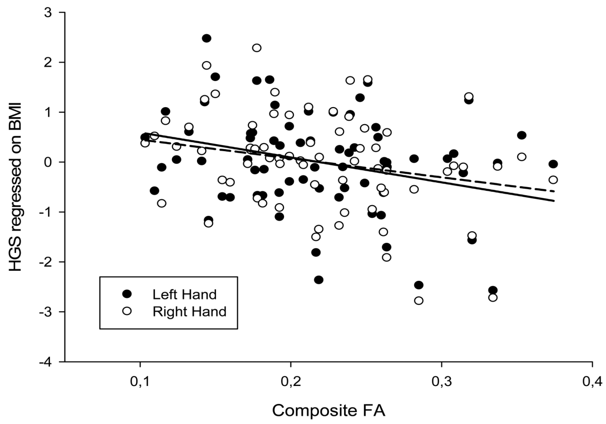

Fig. 1. Scatterplot of associations of right and left HGS regressed on BMI (*res* HGS) with composite FA (12 traits) with regression lines (right hand: solid; left hand: dashed).

DISCUSSION

Our data suggest that in males, body symmetry and physical strength (as measured by HGS) are positively correlated, that is, individuals who exhibit low levels of FA (as a measure of developmental precision) tend to be physically stronger. Our findings were in contrast to that of Van Dongen and Sprengers (2012). The difference may arise because of issues regarding indirect measurement of FA from hand scans (Manning et al., 2006). We suggest that further investigation of the FA and HGS link should use direct rather than indirect body measurements.

Low FA shows negative relationships with attractiveness in a wide range of species, including humans (Gangestad and Thornhill, 2003; Perrett et al., 1999). One explanation of such associations has been that FA indicates developmental health, that is, individuals who are better able to resist developmental stress. Physical and/or behavioral traits in males that correlated with FA, such as facial masculinity, voice quality, and body odor are therefore thought to provide "quality" cues to women (Gangestad and Thornhill, 2003; Hughes et al., 2002; Rikowski and Grammer, 1999). Thornhill and Gangestad (2003) showed that body (and face) FA was negatively associated with male (but not female) facial masculinity (computed from 10 facial measures), thus suggesting that facial masculinity advertises developmental stability in men. Masculinity, dominance, and attractiveness perception of male faces correlate with physical strength (Fink et al., 2007), and this is supported by recent research showing systematic associations of male face shape changes with variation in HGS, such that faces of physically strong males appear robust and have a prominent jaw-line (Windhager et al., 2011).

Our present findings suggest that in males, developmental stability (as indexed via FA) and physical strength are correlated. Hence, healthy males may be better able to resist developmental stress, including possible immunosuppressive effects of testosterone (Folstad and Karter, 1992). This may facilitate them to develop higher muscularity, given the significance of testosterone on the expression of muscle size and physical strength (Bhasin et al., 1996; Finkelstein et al., 2013), which may also have positive consequences on the expression of testosterone related masculine male traits, which reflect high RHP. Thus our findings may explain why physical strength is not only a feature that is important in intra-sexual selection (Muñoz-Reyes et al. 2012; Sell et al., 2009, 2012) but also in inter-sexual selection. However, it also suggests that in males muscular strength may be a measure of male quality independent of its role in mediating male–male interactions. Future research on both male and female assessments of other males should therefore be explicit on the kind of qualities (competitiveness vs. health) and context (inter- vs. intra-sexual selection) they hypothesize to be related to male morphology.

Moreover the stability of correlation of FA and HGS over time remains to be demonstrated. It has been reported that physical strength can be influenced by factors such as nutrition (e.g., Flood et al., 2014) and training (e.g., Aagaard and Andersen, 2010; Harris and Eng, 2010), although a recent study could not identify an effect of early nutrition supplementation on strength (Kulkarni et al., 2014). Yet it seems to be the case that women are more susceptible to such factors than men (e.g., Glenmark et al., 1994; Von Hurst et al., 2013). One of the reasons for this may be found in sex differences of genetic influences on the development of HGS. Isen et al. (2014) report that in a sample of 2,513 adolescent twins the additive genetic variance of HGS over time was much higher in males than in females. Clearly, while heritability of HGS was found to be high in both sexes (~80–90%), females are more susceptible to environmental effects on the development of HGS than males. Isen et al. suggested that androgen-mediated mechanisms might shape the development of HGS in males, but may be of minor importance or absent in females, which seems plausible in view of studies reporting negative relationships of low 2D:4D ratio—a proxy for prenatal androgenization—and HGS in males, but not in females (Fink et al., 2006; Hone et al., 2012).

In conclusion, two large twin studies (Frederiksen et al., 2002; Isen et al., 2014) suggest that HGS is a phenotypic marker of genetic quality and it seems that this is especially the case in human males. Our finding on relationships of FA—a measure of developmental precision and health—and HGS seems to support this suggestion, although further studies including more detailed assessment of factors that account for individual variation and development of HGS are clearly needed.

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