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Handgrip strength predicts sexual behavior, body morphology, and aggression in male college students

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Abstract

Handgrip strength (HGS) is a noninvasive measure of physical health that is negatively correlated with disability, morbidity, and mortality rates in adults. Highly heritable, HGS is indicative of blood testosterone levels and levels of fat-free body mass. In this study, we investigated whether HGS was related to measures of body morphology [shoulder-to-hip ratio (SHR), waist-to-hip ratio, and second-digit-to-fourth-digit ratio (2D:4D)], aggressive behavior, and sexual history in 82 male and 61 female college students. Results showed that HGS was correlated with SHRs, aggressive behavior, age at first sexual intercourse, and promiscuity in males but not in females. HGS appears to be an honest signal for genetic quality in males.

Keywords: Handgrip strength; Testosterone; Shoulder-to-hip ratios; Aggression; Age at first sex; Number of sex partners; Sex differences

1. Introduction

Handgrip strength (HGS) is an easily obtainable measure of physical health and muscle function. It has been used by human auxologists to study development in children (Sartorio, Lafortuna, Pogliaghi, & Trecate, 2002), by surgeons to predict postoperative complications (Klidjian, Foster, Kammerling, Cooper, & Karran, 1980), by epidemiologists and gerontologists to study the effects of aging in human populations (Kerr et al., 2006; Rantanen et al., 1999), and by evolutionary psychologists to test the effects of a sexual assault scenario on the capacity to physically resist forced attempts at copulation (Petralia & Gallup, 2002).

There is good evidence that HGS is a strong indicator of health status, based on the incidence of disability, morbidity, and mortality in adult populations (Giampaoli et al., 1999; Hughes et al., 1997; Laukkanen, Heikkinen, & Kauppinen, 1995). Elderly men who maintain a high HGS are, on average, at a lesser risk for disability and joint impairment. In addition, men with higher grip strength tend to live longer than those with low HGS. HGS (independent of body mass index) is related to mortality not only in elderly men but also in healthy, middle-aged men (Rantanen et al., 2000). HGS corresponds with many morphological features related to health. There are significant positive associations between HGS and bone mineral density (Kritz-Silverstein & Barrett-Connor, 1994; Sinaki, Wahner, & Offord, 1989), protein loss in surgical patients (Windsor & Hill, 1988), and muscle mass (Kallman, Plato, & Tobin, 1990). Varying as a function of age, highest grip strength scores occur between the ages 24 and 39 years (Mathiowetz et al., 1985).

HGS also varies as a function of developmental factors including nutrition, exercise, and health (Geliebter et al., 1997; Hunt, Rowlands, & Johnston, 1985). However, HGS, along with other measures of muscle strength, is strongly influenced by genetic factors (Arden & Spector, 1997; Fredericksen et al., 2002; Reed, Fabsitz, Selby, & Carmelli, 1991). HGS has a heritability coefficient of .65 after being adjusted for effects of weight, height, age, and various anthropometric measures of fatness, muscle mass, and frame size (Reed et al., 1991).

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A number of studies have shown that HGS is both a highly sexually dimorphic and a lateralized anthropometric measurement (Kamarul, Ahmad, & Loh, 2006; Mathiowetz et al., 1985; Petersen, Petrick, Connor, & Conklin, 1989). Men have consistently greater HGS than women throughout life, and right-handers tend to have approximately 10% more strength in the right hand than in the left in both men and women. In contrast, left-handers tend to have equal strength in both hands (Petersen et al., 1989).

The sex difference in HGS is likely due to higher levels of androgenic hormones (Page et al., 2005), greater muscle mass (Kallman et al., 1990), and greater height and weight in boys and men (Kamarul et al., 2006; Kuh et al., 2006). Supplemental increases in testosterone increase HGS as well as lean body mass in elderly men with low serum T (Page et al., 2005; Sih et al., 1997; Wang et al., 2000).

Sartorio et al. (2002) found in an anthropometric examination of 287 boys and girls of different age groups that "age and gender-dependent differences in HG strength (but not differences between d [dominant] and nd [non-dominant] hand) disappear if HG strength is normalized for FFM [fat free mass]" (p. 413). They also found that HGS was negatively correlated with percentage of body fat. As boys and girls mature, boys tend to have higher measures of fat-free mass (FFM) than girls. This trend in body composition continues into adulthood (Kyle et al., 2005).

From an evolutionary perspective, it is interesting to ask why HGS would be such a ubiquitous measure of human health and vitality. Unique to the evolutionary history of humans and all primates were complex adaptations to life in the trees. In addition to good visual acuity and depth perception, life in the arboreal habitat put a unique emphasis on (a) developing sophisticated patterns of brachiation as a means of achieving effective mobility in the canopy and (b) corollary adaptations that function to minimize the chances of falling. HGS was obviously featured prominently in both of these domains. In the present study, we sought to determine whether individual differences in HGS among contemporary humans would account for any observed variance in social and sexual competition.

2. Materials and methods

We investigated HGS in relation to morphological characteristics, behavioral traits, and sexual history among college students. We measured shoulder-to-hip ratios (SHRs) in males and waist-to-hip ratios (WHRs) in females based on their ability to predict past sexual behaviors (Hughes & Gallup, 2003). We also measured the length of the second and fourth digits (2D:4D) of both males and females as another measure of androgen exposure (Manning et al., 2000). Behavioral traits of interest included physical and relational aggression along with physical and relational victimization. Sexual history was also obtained based on responses to an anonymous survey that included questions about age at first sexual intercourse and number of sexual partners.

2.1. Participants

The methods used in this study were approved by the Institutional Review Board at the University at Albany, and all research conformed to the guidelines for the ethical treatment of human subjects. Participants included 61 heterosexual female college students who ranged in age from 18 to 25 years (mean=19.11, S.D.=1.56) and 82 male heterosexual college students who ranged in age from 18 to 28 years (mean=18.85, S.D.=1.68). All participants signed informed consent statements and received course credit for their participation.

2.2. Anthropometrics

Second- and fourth-digit lengths for each hand were recorded with a Vernier caliper using the methodology described by Manning et al. (2000). Measures were taken twice for each finger. Remeasurement reliability was high for each finger (left hand: 2D, r=.984; 4D, r=.989; right hand: 2D, r=.983; 4D, r=.977). Participants were then shown how to use a handheld dynamometer (Lafayette Instruments Model 78010). Each participant was instructed to squeeze the dynamometer as tightly as possible with one hand and then with the other. Measurements (in kilograms) were recorded on three separate squeezes from each hand, alternating between right and left. Maximum HGS of the three trials was used in subsequent analyses.

Shoulder and hip circumference measurements were obtained in males and waist and hip circumference measurements were obtained in females following the method of Hughes and Gallup (2003). The breadth of the same features was also measured using an anthropometer (Lafayette Instruments Large Anthropometer #1290) to investigate the correspondence between circumference and breadth. Shoulder breadth or biacromial breadth is taken with a large sliding caliper just inferior to the acromial processes. Hip breadth or biiliac breadth is taken with a large sliding caliper at the highest point on the lateral iliac crests of the pelvis. Waist breadth was also taken with a large sliding caliper at the narrowest portion of the waist above the pelvic bones. Each measurement was taken twice and averaged. Remeasurement reliability was high in each case: shoulder circumference in males, r=.976; shoulder breadth in males, r=.977; hip circumference in males and females, r=.993; hip breadth in males and females, r=.977; waist circumference in females, r=.829; waist breadth in females, r=.949. We deliberately chose not to measure SHR in females and WHR in males because the way these features correlate with other variables of interest is largely sex specific (see Hughes, Dispenza, & Gallup, 2004).

Table 1
Anthropometric descriptive statistics: mean±S.D. (*n*)

	Maximum HGS		2D:4D		SHR		WHR	
	Left	Right	Left	Right	Circumference	Breadth	Circumference	Breadth
Males	45.75±8.3 (80)	50.34±8.67 (80)	0.98±0.03 (80)	0.97±0.03 (80)	1.18±0.07 (80)	1.52±0.12 (78)	NA	NA
Females	24.86±5.57 (61)	27.25±4.89 (61)	0.99±0.03 (55)	0.99±0.03 (61)	NA	NA	0.74±0.07 (59)	0.73±0.06 (55)

2.3. Survey

After all measurements were obtained, participants were asked to fill out an anonymous survey. The survey included questions about prior social experiences in middle and high school (Newman, Holden, & Delville, 2005) and sexual history. Specifically, participants were asked about how much they physically aggressed, demeaned, embarrassed, teased, excluded, and isolated peers. They were also asked how often they were the victim of these behaviors. Four subscales that measure both high school and middle school aggressiveness and high school and middle school victimization were derived from the social experiences survey.

The high school aggressiveness subscale included the following questions:

1. How often did you hit, kick, or act physically aggressive toward others during high school?
2. How often did you tease someone during high school?
3. How often did you demean, diminish, or embarrass others during high school?
4. How often did you isolate others during high school?
5. How often did you exclude others in high school?

Responses were recorded on a 5-point Likert scale (1=*not at all*, 2=*once or twice*, 3=*occasionally*, 4=*frequently*, 5=*very often*). The mean score of the response to the five questions was calculated to derive the subscale score. The middle school questions were identical to the above questions except that the time period was specified as middle school instead of high school.

The high school victimization subscale included the following questions with the same Likert scale response options:

1. How often were you a victim of physical aggression (hitting, kicking, and physical intimidation) during high school?
2. How often were you a victim of teasing during high school?
3. How often were you demeaned, diminished, or embarrassed by others during high school?
4. How often were you isolated by others during high school?
5. How often were you excluded by others during high school?

The middle school victimization subscale asked the same questions, specifying middle school as the time period of interest. The mean score of the response to the five questions was once again calculated to derive the subscale score.

Participants were also asked to respond to written questions about sexual intercourse, their age at first sexual intercourse, and the number of sexual partners they had.

3. Results

3.1. Sample descriptive statistics of anthropometric data

Table 1 depicts the lateralization and sexual dimorphism of maximum HGS in our sample of college students. In this sample, 88% of the participants were predominantly right-handed. The dominant right hands of these individuals were approximately 9% stronger than their left hands, which is in accord with results reported previously (Kamarul et al., 2006; Petersen et al., 1989). Similarly, the sex difference we obtained in HGS is also in accord with results from other studies. As shown in Table 1, the differences in HGS between the male and female college students in our sample were so large that they are represented by almost nonoverlapping distributions.

Table 1 also gives the mean, standard deviations, and sample size for 2D:4D, SHR, and WHR for the men and women in our sample. The ranges for 2D:4D for left and right hands are consistent with reported data from Manning et al. (2000). Descriptive statistics for SHR in males and WHR in females were consistent with data previously reported by Hughes and Gallup (2003).

3.2. Correlations

Table 2 depicts the correlations among the variables collected from females. One of the few significant correlations in the female sample was between age at first sex and number of sex partners, which was virtually the same as that found by Hughes and Gallup (2003). We found a significant positive correlation between 2D:4D and waist breadth–hip breadth ratio in females. In contrast, however, neither maximum HGS nor WHR correlated with our measures of sexual behavior.

Table 3 shows the correlations among the variables obtained from the male participants. In contrast with females, left and right maximum HGS values were negatively correlated with age at first sex and positively correlated with number of sex partners in males. As was true for females, age at first sex was negatively correlated with number of sex partners but not significantly. Similarly, our results are in the same direction as those reported by Hughes and Gallup (2003) for SHR and age at first sex for males. Both shoulder breadth and shoulder circumference,

Table 2
Pearson correlations (n) between maximum HGS, WHR, 2D:4D, and sexual behaviors in females

	Maximum HGS, left	Maximum HGS, right	Waist circumference–hip circumference ratio	Waist breadth–hip breadth ratio	2D:4D, left	2D:4D, right	Age at first sex
Maximum HGS, right	.728 ** (61)						
Waist circumference–hip circumference ratio	−.146 (59)	−.152 (59)					
Waist breadth–hip breadth ratio	−.148 (55)	−.203 (55)	.686 ** (54)				
2D:4D, left	−.119 (61)	−.028 (61)	.202 (59)	.301 * (55)			
2D:4D, right	−.224 (61)	−.080 (61)	.273 * (59)	.279 * (55)	.686 ** (61)		
Age at first sex	−.006 (54)	−.029 (54)	.010 (53)	.016 (50)	.074 (54)	.056 (54)	
Number of sex partners	−.115 (59)	.003 (59)	.036 (57)	−.019 (53)	.178 (59)	.119 (59)	−.376 ** (53)

* $p<.05$ (two tailed).
** $p<.01$ (two tailed).

independent of hip morphology, were negatively correlated to age at first sex (shoulder breadth: $r=-.254$, $p=.034$, $n=70$; shoulder circumference: $r=-.266$, $p=.025$, $n=71$). Maximum HGS in males was also significantly correlated with shoulder breadth (left: $r=.504$, $p<.001$, $n=80$; right: $r=.363$, $p=.001$, $n=80$) and shoulder circumference (left: $r=.589$ $p<.001$, $n=82$; right, $r=.423$, $p<.001$, $n=82$).

A high school and middle school bullying subscale was derived for each participant based on his or her answers to the social experiences section of the survey. The subscale scores include information about physical as well as relational victimization. In males (see Table 4), maximum HGS for the left hand significantly correlated with the high school aggression subscale score (maximum HGS, left: $r=.302$, $p<.01$, $n=82$). In other words, male participants who self-reported more aggressive behaviors toward their peers while growing up had stronger grip strength. Left-hand 2D:4D also correlated with aggressive behaviors among males in high school ($r=-.267$, $p=.015$, $n=82$). The victimization subscales and the middle school bully subscale showed no relationship with HGS.

4. Discussion

Male HGS predicted aspects of body morphology, past aggressive behavior, and sexual behavior. As HGS went up, males tended to have broader shoulders, were more aggressive, had sex at an earlier age, and reported having more sex partners. These results showing a relationship between male HGS, body morphology, and sexual behavior have been recently replicated (Shoup & Gallup, 2007). HGS appears to be related to an ensemble of masculine-specific characteristics, and we believe that HGS in males is an indicator of selection during evolutionary history for overall physical strength among males. This may explain why female participants showed no relationship between HGS and any of these measures.

Sexual dimorphism in body size and body configuration reflects differences in reproductive strategies and mate choice. Hughes and Gallup (2003) found that WHR in college women was correlated with age at first sex and number of sex partners, whereas SHR was correlated with these same measures in men. In our study, shoulder breadth and shoulder circumference predicted age at first sex in males, but we found no correlation between sexual behavior and SHR or WHR. Shoulder breadth and shoulder circumference also predicted maximum HGS for both right hand and left hand in males, while SHR correlated with left-hand maximum HGS.

As SHR increases in men, body appearance generally becomes more triangular or wedge shaped. Based on findings by Sartorio et al. (2002) and Kyle et al. (2005), it is reasonable to suppose that this pattern is related to FFM

Table 3
Pearson correlations (n) between maximum HGS, SHR, 2D:4D, shoulder circumference and breadth, and sexual behaviors in males

	Maximum HGS, left	Maximum HGS, right	Shoulder circumference–hip circumference ratio	Shoulder breadth–hip breadth ratio	2D:4D, left	2D:4D, right	Age at first sex
Maximum HGS, right	.816 ** (82)						
Shoulder circumference–hip circumference ratio	.218 * (82)	.116 (82)					
Shoulder breadth–hip breadth ratio	.242 * (80)	.098 (80)	.374 ** (80)				
2D:4D, left	−.139 (82)	−.081 (82)	−.161 (82)	−.057 (80)			
2D:4D, right	−.083 (82)	.004 (82)	−.059 (82)	−.015 (80)	.577 ** (82)		
Age at first sex	−.247 * (71)	−.237 * (71)	−.063 (71)	−.224 (70)	−.171 (71)	−.226 (71)	
Number of sex partners	.330 ** (75)	.270 * (75)	.142 (75)	.038 (73)	−.069 (75)	−.039 (71)	−.231 (70)

* $p<.05$ (two tailed).
** $p<.01$ (two tailed).

Table 4
Pearson correlations (n) between maximum HGS and physical and relational aggression and victimization subscales

	Maximum HGS, left	Maximum HGS, right	High school victim subscale	Middle school victim subscale	High school aggression subscale
Females					
High school victim subscale	−.090 (61)	−.108 (61)			
Middle school victim subscale	.086 (61)	−.024 (61)	.725 ** (61)		
High school aggression subscale	−.111 (61)	−.160 (61)	.332 ** (61)	.303 * (61)	
Middle school aggression subscale	.042 (61)	.015 (61)	.239 (61)	.151 (61)	.689 ** (61)
Males					
High school victim subscale	−.042 (82)	.067 (82)			
Middle school victim subscale	.096 (82)	.116 (82)	.669 ** (82)		
High school aggression subscale	.302 ** (82)	.193 (82)	.286 ** (82)	.178 (82)	
Middle school aggression subscale	.111 (82)	.123 (82)	.266 * (82)	.266 * (82)	.64 ** (82)

* $p<.05$ (two tailed).
** $p<.01$ (two tailed).

and other aspects of masculinity. Our data show that HGS and shoulder breadth not only correlate with each other but are also both good indicators of sexual history (age at first sex).

Aggressive behavior was measured using a survey including questions associated with bullying behaviors during adolescence. HGS was positively correlated with behaviors such as physical aggression, verbal teasing, and demeaning. Physically strong adolescent males (as measured by HGS) were more socially aggressive while growing up. These findings could have important implications for how we look at bullying behavior in males as it relates to hierarchy formation, social dominance, and reproductive success.

One of the most substantial correlations to emerge from our analysis was the relationship between HGS and number of sex partners in males (i.e., HGS accounted for more than 10% of the variance in male promiscuity). Males with higher HGS not only had more sexual partners but also began having sex at an earlier age. This may be a consequence of the fact that males with high HGS scores are more masculine in both physical and social characteristics and therefore are seen by females as more desirable short-term mates (Frederick & Haselton, 2007).

Previous research has shown that HGS is a significant predictor of health status, postoperative recovery, longevity, reduced disability, reduced morbidity, recovery from injury, protein loss, bone mineral density, muscle mass, and percentage of body fat. These findings, coupled with our behavioral and morphological data, support the idea that HGS may be a good predictor of genetic quality in males. Indeed, we predict that HGS may also correlate with other masculine physical features such as facial attractiveness. Research has shown that male facial attractiveness predicts masculine-specific characteristics and may also signal quality genes (Johnston, Hagel, Franklin, Fink, & Grammer, 2001; Schieb, Gangestad, & Thornhill, 1999; Thornhill & Gangestad, 1999). It is important to note, however, that these effects can vary depending on partnership status, temporal context, and hormonal status as related to where the female rater is across her menstrual cycle (Johnston et al., 2001; Little, Jones, Penton-Voak, Burt, & Perrett, 2002).

We suspect that one of the leading factors playing a role in the variation of HGS among males is testosterone levels. It has been repeatedly shown that when testosterone is increased in men with low serum T, HGS increases (Page et al., 2005; Sih et al., 1997; Wang et al., 2000; however, see Malkin et al., 2006, for an exception). Testosterone supplements have been shown to boost rehabilitation effects in elderly men (Bakhshi, Elliott, Gentili, Godshalk, & Mulligan, 2000). It has also been widely observed that testosterone levels are related to aggressive behavior and variation in masculine-specific body configuration (Book, Starzyk, & Quinsey, 2001; Hansen, Bangsbo, Twisk, & Klausen, 1999; Higley et al., 1996; Scerbo & Kolko, 1994; Tremblay, 1998; Wang et al., 2000). As to female variation in testosterone, the range of variation in T is much more truncated and may explain the absence of similar correlations.

FFM has also been shown to be a major contributing factor to HGS (Sartorio et al., 2002), and testosterone replacement increases FFM in hypogonadal men (Bhasin et al., 1997). If testosterone levels contribute to HGS in males, it may explain the aggressive behavior, observed masculine-specific body morphology, and promiscuity we found to be associated with HGS. Further research should investigate the association between HGS and blood/salivary testosterone levels.

We believe that HGS is an easily obtainable and reliable measure and may be valuable in studying human behavior from an evolutionary perspective. Considering that the research on 2D:4D often yields inconsistent results (Bailey & Hurd, 2005; Benderlioglu & Nelson, 2004; Lippa, 2006; Millet & Dewitte, 2006; Moore, Quinter, & Freeman, 2005; Putz, Gaulin, Sporter, & McBurney, 2004; Rahman, Korhonen, & Aslam, 2005), HGS may serve as a useful supplemental variable. As further evidence of the inconsistency in 2D:4D research results, our findings failed to replicate Fink et al. (2006) in showing a relationship between HGS and 2D:4D.

Whereas HGS is a powerful predictor of health and vitality in both men and women, in the present study, we found that its relationship to sexual behavior and body morphology was restricted almost exclusively to men. One account of this gender asymmetry in HGS as a fitness indicator is that it might be a consequence of the fact that upon coming down from the trees, a primitive division of labor emerged that put a premium on the maintenance and further elaboration of grip strength in men. Competition among men for scarce resources, hunting, and tool use over the past several million years may have been some of the gender-specific vectors for the sex differences we observed.

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