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RESEARCH

Associations Between Intelligence and Anthropometric Traits: Evidence from a U.S. Sample of Young Men

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Abstract
Genetic quality may be expressed through many traits simultaneously, suggesting a phenotype-wide fitness factor. In humans, intelligence has been positively linked with potential indicators of genetic quality, including anthropometric characteristics. We conducted an exploratory study of the relationships between fluid intelligence (assessed by the Raven Advanced Progressive Matrices Test – Short Form), sexual promiscuity (assessed by the Sociosexuality Orientation Inventory – Revised), and two measures of male muscularity and body morphology—handgrip strength (HGS) and shoulder-to-hip ratio (SHR)—in a sample of 41 men (ranging 18 to 33 years; M = 23.33; SD = 3.60). We detected statistically significant positive relationships between intelligence and HGS and SHR in young men (but no significant correlations between HGS and SHR). In addition, sexually promiscuous behaviors were negatively associated with intelligence and SHR. We discuss these preliminary results in relation to a phenotype-wide fitness factor and address several limitations of this study.

Keywords Phenotype-wide fitness factor · Intelligence · Handgrip strength · Shoulder-to-hip ratio · Sociosexuality

Pleiotropic genes influence multiple phenotypic traits. Human research provides evidence of pleiotropic effects that facilitate and constrain functional traits. For example, a set of specific genes has been linked to traits associated with high-altitude adaptation in Tibetans, such as low hemoglobin production and stable heart rates under hypoxia (Nelson et al., 2019). Conversely, the genetic mutations that cause cystic fibrosis also cause male infertility, and jointly reduce overall fitness, even though these conditions affect different biological systems (respiratory and reproductive; Sokol, 2001). Along these lines, some theoretical work has proposed a phenotype-wide fitness factor, suggesting that all phenotypic indications of fitness for a given species are linked.

One possible explanation for the mechanism underlying a phenotype-wide fitness factor is mutation load, since mutations often have pleiotropic effects that can impact functional traits. Some theoretical perspectives suggest individuals with low mutation loads should experience fewer detrimental effects across phenotypic traits (e.g., Houle, 2000; Miller, 2000). Further, some research suggests that intelligence is a proxy for high genetic quality and thus low mutation load. Hill and colleagues (2019) found that cognitive ability and health share a common genetic background. Additionally, several studies have observed positive links between intelligence and physical health (Arden et al. 2009a, b; Fries and Pietschnig 2022), male fertility and ejaculate quality (Arden et al. 2009a, b; Kolk and Barclay 2020), body symmetry (Prokosch et al., 2005), and body height (Silventoinen et al., 2006), suggesting that intelligence may correlate positively with overall fitness. However, individual fitness factors may not be the best predictor of overall reproductive success. According to a meta-analysis by Reeve et al. (2018), when both female and male

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fertility indicators are considered together, there is a strong negative relationship between intelligence and the number of children produced. This complexity necessitates further research to clarify the association between intelligence and overall fitness.

If intelligence is a proxy for genetic quality and low mutation load, then it should also positively correlate with other anthropometric indicators of genetic quality established in previous research. Positive relationships between handgrip strength (HGS; a measure of muscularity) and shoulder-to-hip ratio (SHR; an indicator of body shape) with health have been documented among men (Law et al., 1992; Shoup & Gallup, 2008; Vaishya et al., 2024). However, their relationships with intelligence have received less scholarly attention. Research shows that HGS predicts cognitive decline in older adults (Cui et al., 2021; Dercon et al., 2021). Specifically, older adults without cognitive impairment who have lower HGS are at an increased risk of experiencing subsequent cognitive decline. In younger adults, studies have reported a negative association between HGS and age-related cognitive decline (Choudhary et al., 2016) and a positive association between HGS and gray matter volume (Jiang et al., 2022). Research also documents positive associations between HGS and intelligence (as assessed by the Kaufman Brief Intelligence Test, which shows correspondence with the more widely known Revised Wechsler Intelligence Scale for Children) in a sample of individuals with intellectual disability (Cabeza-Ruiz et al., 2021; Kaufman & Kaufman, 2004; Wechsler, 1974). Collectively, the literature suggests a connection between phenotypic traits signaling high genetic quality and cognitive functioning. However, direct investigations of associations between HGS and validated intelligence measures (e.g., Wechsler Adult Intelligence Test - WAIS, Raven's Advanced Progressive Matrices - RAPM) rather than proprietary tests that correlate with validated intelligence measures, and among younger, cognitively unimpaired adults, are a relatively neglected area. Considering the established positive correlations between HGS, SHR, and health outcomes, it is reasonable to propose that a positive relationship between HGS, SHR, and intelligence may collectively represent an indicator of overall fitness.

Furthermore, higher male SHR may be linked to traits reflecting genetic quality and sexual behavior. Men with higher SHR are rated higher in physical attractiveness by both men and women, self-report having earlier sexual debuts, more sexual partners, and more incidents of extra-pair copulations with partnered women (Hughes & Gallup, 2003). SHR is positively associated with HGS (Gallup et al., 2007), and both are indicators of male muscularity (Gallup & Fink, 2018), with greater muscle mass associated with better health (Abramowitz et al., 2018). SHR and HGS both positively correlate with body symmetry (Brown et al., 2008; Fink et al., 2014), and the latter is positively associated with intelligence (as measured by Raven's Advanced Progressive Matrices; Prokosch et al., 2005).

Despite the observed associations among anthropometric, cognitive, and behavioral fitness indicators, certain studies present evidence that challenges pleiotropic fitness theories. Some work suggests that higher intelligence might hinder reproductive success. Indeed, higher intelligence is associated with an increased propensity to endorse evolutionarily novel ideas (e.g., liberalism, atheism) and to place a higher value on sexual exclusivity (Kanazawa 2010a). For men, sexual exclusivity may reflect an evolutionarily novel strategy compared to humans' polygynous ancestral history. Consequently, greater overall genetic quality may not advance all pertinent fitness domains, particularly in evolutionarily novel environments. For contemporary humans, this suggests a potential disparity between general fitness and reproductive success.

Thus, the present study intended to clarify and extend past research by investigating, concurrently, associations of HGS, SHR, and sexual promiscuity with intelligence in a sample of young men attending a Midwestern university in the United States. Specifically: (1) we measured intelligence using the Raven Advanced Progressive Matrices Test – Short Form (Arthur & Day, 1994); (2) we adopted a theory-guided approach in our methodology and predictions, to supplement the largely atheoretical literature; (3) we, therefore, situate intelligence as part of a phenotype-wide fitness factor by investigating its association with HGS and SHR, controlling for body mass index (BMI; calculated from height and weight measurements), as larger males have greater HGS (Nicolay & Walker, 2005); (4) we attempted to clarify the inconsistent findings on the relationship between sexual promiscuity and intelligence by including a measure of sexual promiscuity via the Sociosexual Orientation Inventory – Revised (SOI-R; Penke & Asendorpf, 2008); (5) relatedly, we focused exclusively on men, given their greater variability in phenotypic quality (including intelligence and sexual promiscuity) relative to women, likely due to greater male ancestral reproductive variance (Arden & Plomin, 2006; Wyman & Rowe, 2014).

Method

Participants

The current study reports novel analyses of data from a larger project primarily investigating individual differences in ejaculate quality (Pham, et al., 2018). The initial dataset included responses from 66 men (ranging 18 to 34 years; $M=22.77$; $SD=3.83$) who attended at least two of the three total study sessions at a Midwestern university in the United States. The original sample comprised 69.7% White ("Caucasian") men, 9.1% African American men, 4.5% Asian American men, and the remainder identifying with the ethnic categories of Indian, Hispanic, or Other. Only data from participants who completed all study procedures were included in the current analyses. The final sample included 41 men attending a Midwestern university in the United States, with ages ranging 18 to 33 years ($M=23.33$; $SD=3.60$; 78.0% of the sample was "Caucasian"; see Pham, et al., 2018).

Measures

Intelligence We measured intelligence with the Raven Advanced Progressive Matrices Test – Short Form (Raven-SF; Arthur & Day, 1994). The Raven-SF consists of 12 design problems, whereby participants choose from possible design choices to continue the pattern displayed in the design problem. Individual item scores are summed to produce a final score. Every correct response counts as one point, for a maximum of 12 points. Previous research using the Raven-SF reported Cronbach's alpha reliabilities between 0.58 and 0.66 (Arthur et al., 1999). In the current study, Cronbach's alpha was 0.59.

Sexual Promiscuity We measured promiscuity with the Sociosexual Orientation Inventory – Revised (SOI–R; Penke & Asendorpf, 2008). The SOI-R consists of nine self-report items that assess three dimensions of sociosexuality: desires, attitudes, and behaviors (with three items per dimension). Items are scored on a Likert-scale ranging from 1 to 9, such that higher scores on each item correspond to more unrestricted sociosexuality (i.e., greater propensity toward casual sex), and items were averaged to create scale scores. We focused on the behavior section, as it more accurately reflects actual sexual promiscuity than the overall SOI-R score. In the current study, the alpha reliability for the total SOI-R was 0.84, and 0.65 for the behavior portion.

Handgrip Strength (HGS) HGS was measured with a CAMRY digital hand dynamometer (SCACAM-EH10117; South El Monte, CA). In a university lab setting, participants were instructed to pull back on the dynamometer as far as possible while seated, and an experimenter recorded the value in kilograms displayed on the dynamometer. Participants performed three tests for both the left and right hands, and averages were computed for each hand (using the three measurements for each hand). Pearson's correlation coefficients (r) between all hand assessments ranged between 0.85 and 0.95.

Shoulder-to-Hip Ratio (SHR) In a university lab setting, an experimenter measured the circumference of participants' shoulders and hips in centimeters using a 1.524 m tape measure (Sona Enterprises, Santa Fe Springs, CA), wrapped around the broadest points of the participants' shoulders and hips. Participants were instructed to stand up straight with their arms straight down during measurements. To calculate SHR, the shoulder measurement was divided by the hip measurement.

Height, Weight, and Body Mass Index BMI was calculated through measures of both height and weight. We measured height in centimeters and weight in kilograms using a digital scale with a height-measuring rod (Detecto, Webb City, MO). Once these measures were obtained, we calculated BMI by converting height to meters and then using the formula of weight in kilograms divided by height (in meters) squared.

Procedures

Procedures were approved by the institutional review board of the university where the data were collected. Participants were recruited by posting advertisements on bulletin boards on the university campus. Prospective participants contacted the lab to schedule a visit. Upon arriving at the lab, participants were escorted to a private room to complete the Raven-SF and SOI-R on a computer. Then, an experimenter collected several anthropometric measurements (including HGS, SHR, body height, and weight). Participants were informed about the purpose of the study, provided written consent, and received US$25 after each session.

Results

Table 1 presents descriptive statistics for the study variables. There were significant positive correlations between intelligence and left HGS (r = .35, p = .024) and SHR (r = .43, p = .006). Conversely, there was a significant negative correlation between intelligence and sexually promiscuous behaviors (behavior domain of the SOI-R; $r=-.35$, p = .026). However, the correlation between overall sociosexuality and intelligence was not significant (SOI-R composite; $r=-.14$, p = .368). Similarly, the correlations between left HGS and SHR (r = .10, p = .545) and right HGS and SHR ($r=-.03$, p = .866) were not significant.

Table 1 Descriptive statistics for target variables

Target variable	Mean	SD	Skewness	Kurtosis
Intelligence	7.02	1.98	0.84	-0.49
Sociosexuality – composite	4.23	1.61	0.05	-0.69
Sociosexuality - behavior	2.86	1.47	2.48	-0.04
Left hand grip strength	38.95	10.80	-0.35	-1.11
Right hand grip strength	42.52	9.65	-0.92	-0.42
Body Mass Index	27.20	5.10	1.32	3.64
Shoulder-to-hip ratio	1.15	0.08	-0.14	-0.95

See text for variable definitions; $n=41$

We also calculated correlations between anthropometric measures, sexual promiscuity, and intelligence for the original sample of 66 men who attended at least two of the three study sessions. With this larger sample, the positive correlations between right HGS (r = .26, p = .048) and left HGS (r = .30, p = .024) and intelligence were statistically significant, but not the correlation of SHR with intelligence (r = .03, p = .820) or sexual promiscuity with intelligence (r = .064, p = .616). Lastly, we included anthropometric traits (right and left HGS, SHR, and BMI) in a multiple regression predicting intelligence (for the sample of 41 men). The overall model was significant, but only SHR was marginally significant (Table 2).

Following Arden and colleagues (2009), we conducted an exploratory factor analysis to test the hypothesized presence of a fitness factor underlying phenotypic traits. Specifically, we used principal axis factoring with Promax rotation, incorporating all relevant variables: SHR, left and right HGS, BMI, Raven's scores, and SOI-R behavioral scores. The first factor was approximately normally distributed, explained about 32% of the variance among the measures, and appeared to reflect grip strength/muscularity. The Raven's scores showed higher loading on the second factor, which appeared to reflect greater overall fitness (see Table 3 for the factor loadings of all three factors). The Kaiser-Meyer–Olkin measure of sampling adequacy was 0.558. Bartlett's test of sphericity indicated that the correlation matrix was not an identity matrix but had sufficient non-random structure to allow factor analysis (*Chi-squared*=76.79, df=15, p < .001).

Table 3 Results of an exploratory factor analysis of the target variables

Target variables	Factor 1 (Grip strength)	Factor 2 (Overall fitness)	Factor 3 (Body size)
Intelligence	0.191	0.613	−0.146
Shoulder-to-hip ratio	−0.087	0.751	0.201
Body mass index	0.080	−0.029	0.465
Left hand grip strength	0.921	0.074	−0.002
Right hand grip strength	0.965	−0.090	0.055
Sexual promiscuity	0.064	−0.574	0.103
% variance explained	32.45	19.39	4.81

Discussion

We investigated whether intelligence correlates positively with the anthropometric measures of HGS and SHR, as well as with sexual promiscuity. We found that SHR and left HGS were positively associated with intelligence in a small sample of young men. The association with intelligence extended to HGS in both hands (but not to SHR) when analyzing a larger sample of men. Among the anthropometric traits measured, including BMI as a covariate, SHR emerged as the sole significant predictor of intelligence, although the statistical significance was marginal. This relationship was further corroborated by findings from an exploratory factor analysis. These findings are consistent with the phenotype-wide fitness factor hypothesis (Houle, 2000) and with research documenting that current HGS predicts future cognitive decline in older adults (e.g., Cui et al., 2021; Dercon et al., 2021). The results further suggest that HGS is related to individual differences in cognitive abilities (including intelligence) in young adults. However, we also found a negative correlation between sexual promiscuity and intelligence, which contrasts with theories of pleiotropic fitness (Houle, 2000; Miller, 2000), and the positive associations between anthropometric traits (including HGS and SHR) and sexual promiscuity observed by Gallup et al. (2007). Conversely, this pattern of results does support the negative correlation between intelligence and fertility observed by Reeve and colleagues (2018) as well as the link between higher intelligence and evolutionarily novel behavior and

Table 2 Multiple regression predicting intelligence from phenotypic traits

Overall model		R^2		F		p
		0.32		3.22		0.017
Phenotypic traits	*B*	*β*	*SE*	*t*		*p*
Sexual promiscuity	-0.33	-0.22	0.24	-1.41		0.168
Shoulder-to-hip ratio	8.78	0.310	4.47	1.96		0.058
Left hand grip strength	0.07	0.32	0.07	1.04		0.304
Right hand grip strength	-0.01	-0.03	0.07	-0.09		0.929
Body Mass Index	-0.04	−0.09	0.06	-0.59		0.557

Bolded values are significant at the 0.05 level. Covariate: BMI. Phenotypic traits: sexual promiscuity, shoulder-to-hip ratio, left hand grip strength, and right hand grip strength. n=41 cognition (i.e., sexual exclusivity rather than promiscuity; Kanazawa 2010a).

Taken together, the current results suggest a more nuanced picture of how traits indicative of genetic quality relate to overall fitness. Positive associations between HGS, SHR, and intelligence suggest an overall fitness factor as discussed in previous literature (Houle, 2000; Miller, 2000), especially given that these associations were detected despite the small sample size. The negative association between sexual promiscuity and intelligence may be incongruent with an overall fitness factor, as increased mating success should be linked to overall fitness. However, sexual promiscuity is not itself an indicator of reproductive success, and future research may benefit from investigating the relationship between intelligence and other potential indicators of reproductive success. For example, reproductive success may also be achieved through monogamous relationships. Indeed, intelligence is positively correlated with the likelihood of getting married and staying married (Aspara et al., 2018), which supports the proposal that sexual exclusivity (especially for men) may be a more evolutionarily novel mating arrangement compared to polygyny and that general intelligence may facilitate solutions to evolutionarily novel problems (Kanazawa 2010a).

The present study has several limitations. One limitation is that we did not record the participants' dominant hand, which may affect HGS measurements; however, the evidence for this possibility is inconsistent across studies (e.g., Nicolay & Walker, 2005; Noonari et al., 2019). Additionally, the current investigation used a small sample of 41 men. These data were part of a larger study on individual differences in ejaculate quality (Pham et al., 2018), and small sample sizes (with a more limited age range to control for age-related declines in ejaculate quality) are a recurrent limitation of psychological research investigating ejaculate quality (e.g., Baker & Bellis, 1989). As such, the current results may not be representative of the general population. Future research should examine the relationship between intelligence and phenotypic traits using larger (and more generalizable) samples, as small effect sizes for the relationship between HGS and intelligence may be negligible after adjustments for multiple tests of this relationship. Finally, the use of the Raven's measure of intelligence may be considered a limitation given research suggesting that it only shares approximately 50% of variance with *g* (general intelligence factor) and that the Wechsler scales (for example) perform better and with a higher *g* validity coefficient of 0.93 (Gignac, 2015). Overall, the current study suggests that intelligence, HGS, and SHR each may indicate a general fitness factor. However, any such conclusions should be interpreted with caution, given the limitations detailed above.

The present study investigated intelligence-phenotypic relationships in a small sample of young, college-educated men from the U.S. and could benefit from expansion to more diverse populations and other validated intelligence measures. Despite its exploratory nature, the study adds to the small body of research on the relationship between phenotypic traits and a validated measure of intelligence (the Raven - SF) in cognitively unimpaired young men.

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Data Availability Data is available from the corresponding author upon request.

Declarations

Ethical Considerations This study was approved by the Ethics Committee of Oakland University (Ethics Code: 00000087) on 9/1/2012. All participants provided written informed consent prior to enrollment in the study. This research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki.

Consent for Publication Not applicable.

Consent to Participate All participants provided written informed consent prior to participating.

Competing interests The authors declare no competing interests.

Clinical Trial Number Not applicable.

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