

# The factorial structure of self-reported androgen-promoted physiological traits

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## ABSTRACT

Androgens make major contributions to average sex differences in anatomy, physiology, and behavior. Despite having established their crucial role in sexual differentiation, much remains to be learned about how androgens coordinate their influences. The present study was undertaken to shed light on androgenic effects on the body using self-reported survey data. We analyzed the ratings provided by over 11,000 college students on the magnitude of eleven traits that previous research has shown to be influenced by testosterone or other androgens. Predictably, the average values for all eleven traits were significantly greater in males than in females. Nevertheless, when data were analyzed separately according to sex of the respondents, some of the traits failed to positively correlate with one another, suggesting that not all androgen-influenced traits differentiate in a simple fashion. Factor analysis of these eleven traits by sex reinforced this view by identifying four factors. In men, the primary factor loaded most heavily on: masculine body build, masculine mannerisms, overall physical strength, upper body strength, and lower body strength. The primary factor for women was limited to: upper body strength, lower body strength, and overall physical strength. In both sexes, the primary factor was interpreted as reflecting the influence of perinatal and postpubertal testosterone exposure. The other three factors may reflect the effects of other androgens (e.g., androstenediol), or the influence of female hormones such as estradiol. Findings were discussed in terms of future use of self-reported physiological measures for assessing androgenic effects on the human body.

**Keywords:** Androgen-promoted physical traits;

Testosterone; Masculinization; Physical strength; Factorial structure; Sex differences

## 1. INTRODUCTION

A recent literature review provided evidence that the sexes differ in a myriad of ways, ranging from easy-to-measure traits (e.g., birth weights and adult body size) to many complex characteristics (e.g., susceptibility to numerous diseases, detailed biochemistry, neurology, perceptual sensitivities, motor coordination, and even many cognitive and behavioral patterns) [1]. This evidence raises questions about how sex differences are produced. Although the details are still far from fully understood, numerous studies have implicated bodily exposure to androgens as primarily responsible for sex differences in traits [2-5].

In broad terms, the sexual differentiation of animals occurs as follows: The default sex at least for mammals, is female, meaning that males are a genetic variant on the female sex [6-9]. Early in the gestation process of nearly all males, the would-be ovaries are made to begin differentiating into testes instead by genes located on the Y-chromosome [10]. As this occurs in humans during the first five months of gestation, the genitals of males gradually take on a masculine rather than a feminine appearance [11-12].

The gestational aspects of sexual differentiation are referred to as its organizational stage, a stage in humans extending from the first month of gestation into about the fourth month following birth [13]. The second phase of sexual differentiation is known as the activational (or postpubertal) stage. It is marked by the appearance of so-called secondary sex characteristics, but also includes enlargement of the penis and testes in males [14-17].

The traits that are masculinized by bodily exposure to androgens are numerous. They include the following:

- Growth of body hair [18-20]
- Darkening of the iris of the eye [21,22]
- Facial acne [23-25]

- Darkening of hair color [26,27]
- Increase in height [28-32]
- Lowering of the voice [33-37]
- Increase in upper body strength [15,38,39]
- Increase in lower body strength [40,42]
- Increase in masculine body appearance [43-44]
- Increase in masculine mannerisms [45,46]

Despite the abundant evidence that androgens masculinize many aspects of human development, the details are still only vaguely understood. The purpose of the present study was to examine the eleven androgen-influenced traits listed above using self-ratings, with the following three questions in mind. First, are all of these traits in fact sexually dimorphic? Second, within each sex, how well do the eleven traits correlate with one another? Third, do the within-sex expressions of these traits cluster together, thereby suggesting that they may be resulting from a limited number of similar androgenic regimens?

## 2. METHODS

As part of a broad-ranging investigation, a standardized questionnaire was completed by a large sample of college students at twenty United States and two Canadian universities between 1988 and 1998 involving 3,786 males and 7,697 females [47]. Subjects ranged in age from 18 to 56, with a mean of 22 for both sexes. In terms of race and ethnicity, the subjects were 85% white, 4% black, 2% Native American, 2% Asian / Pacific Islander, 1% Hispanic, and 6% providing no answer.

Eight of the androgen-promoted physiological traits were measured by asking subjects to rate themselves regarding each trait using a 1 to 100 scale, with 100 representing maximum expression of each trait. These eight traits were: masculine mannerisms, masculine body appearance, physical strength, low deep voice, upper body strength, lower body strength, body-hair development, and facial acne. Height was measured simply in terms of feet and inches (converted to inches). Eye color and hair color were measured, first, by asking subjects to give a one- or two-word description of their eye color and natural hair color. These descriptions were then interpreted and transcribed into four categories. From highest to lowest values, eye color was coded as being Black, Brown, Hazel / Green, and Blue. For hair color, the four categories were Black, Dark Brown, Light Brown, and Blond. (A copy of the questionnaire is available upon request)

Analysis was carried out in three stages. First, the sexes were compared regarding their average scores on all eleven traits using a *t*-test. Second, to determine how well the eleven traits correlated with one another, a correlation matrix was created for the sexes separately.

Third, factorial analysis was performed on the eleven traits to assess whether or not some of the traits would form into clusters.

## 3. RESULTS

**Table 1** shows that all eleven androgen-promoted traits are significantly more pronounced in men than in women, with  $p = 0.000$  in all cases except for eye color (which attained significance only at the 0.05 level). This is entirely predictable, given that the levels of testosterone (and other androgens) are higher for males than for females throughout both the organizational and activation stages of sexual differentiation ([1], pp. 89-93).

**Table 2**, however, reveals that *within* each sex, some of the androgen-promoted traits are not positively correlated with one another. Such a rather surprising finding can be interpreted as suggesting that the enhancement of androgen-promoted traits does not occur through a unitary process. Most notably, the variables of eye color and especially adolescent facial acne correlate negatively with many of the other androgen-influenced traits among both sexes.

The results for factor analyzing responses regarding the eleven androgen-promoted traits are presented in **Table 3** for each sex separately. Regarding males (**Table 3(a)**), the first factor to emerge was named *masculinity / strength* since it was comprised of masculine mannerisms, masculine body build, and all three of the physical strength measures. We named the second factor *pigment* because it only loaded strongly on hair color and eye color. Body hair development and adolescent facial acne loaded most heavily on the third factor (with some secondarily strong loadings on upper and lower body strength), which was named *dark pigmentation*. Finally, height and low-deep voice comprised a fourth factor, which we named *physical prowess* since both height and low-deep voice are likely to have evolved primarily to intimidate rivals (and possibly impress prospective mates).

Turning to females (**Table 3(b)**), four factors also emerged. The first factor had to do with *strength*. Masculine mannerisms and body build loaded along with low-deep voice onto a second factor; therefore, we called it *female masculinity*. The remaining two female factors were identical to those in males, a *dark pigmentation* factor and a *skin-hair* factor. It is interesting to note that height loaded heavily on the physical prowess factor in males but failed to load on any factor among females.

## 4. CONCLUSIONS

While there is no doubt that androgens play a pivotal role in differentiating males from females, much remains

**Table 1.** Descriptive statistics for androgen-promoted physical traits by comparing males with females.

Traits	N	Mean	Std. Dev	Effect Size (d)	Variance Explained	Std. Error Mean	t-Test Results for Equality of Means
Masculine Mannerisms							
Female	7,456	21.84	21.89	2.59	0.62	0.254	132.748***
Male	3,757	74.88	74.88			0.309	
Masculine Body Appearance							
Female	7,447	12.90	19.27	3.32	0.74	0.223	165.808***
Male	3,767	76.82	19.29			0.314	
Physical Strength							
Female	7,697	60.48	18.89	0.52	0.06	0.215	26.473***
Male	3,786	70.00	17.72			0.288	
Height							
Female	6,655	65.15	2.70	2.05	0.51	0.033	95.150***
Male	3,282	70.88	2.88			0.050	
Low Deep Voice							
Female	6,540	21.22	24.84	1.38	0.32	0.307	64.699***
Male	3,217	54.98	23.92			0.422	
Upper Body Strength							
Female	5,016	52.46	22.12	0.41	0.04	0.314	16.698***
Male	2,483	61.57	22.23			0.446	
Lower Body Strength							
Female	5,834	57.91	21.19	0.38	0.03	0.279	16.136***
Male	2,827	65.72	21.01			0.395	
Body-Hair Development							
Female	5,806	46.56	21.64	0.24	0.01	0.285	10.304***
Male	2,828	52.06	23.96			0.451	
Facial Acne							
Female	5,793	29.88	25.73	0.17	0.008	0.338	7.699***
Male	2,816	34.39	25.42			0.479	
Hair Color							
Female	6,399	2.47	1.01	0.21	0.01	0.013	9.762***
Male	3,128	2.68	0.99			0.018	
Eye Color							
Female	3,881	1.84	0.90	0.05	0.003	0.014	2.249*
Male	2,002	1.89	0.92			0.021	

Notes: p < 0.001 = \*\*\*, p < 0.01 = \*\*, and p < 0.05 = \*; d = Cohen's d

**Table 2.** Inter-correlation matrix for androgen-promoted traits by sex. The coefficients for males (bolded) appear in the upper right quadrant; those for females (italicized) are in the lower left quadrant (the sample sizes used in calculating each correlation are represented in parentheses).

	Masculine Mannerism	Masculine Body Build	Physical Strength	Height in inches	Low-Deep Voice	Upper Body Strength	Lower Body Strength	Body Hair	Facial Acne	Hair-color	Eye-color
Masculine Mannerisms	1	<b>0.737**</b> (3,751)	<b>0.464**</b> (3,756)	<b>0.053**</b> (3,246)	<b>0.190**</b> (3,193)	<b>0.326**</b> (2,458)	<b>0.285**</b> (2,804)	<b>0.129**</b> (2,813)	<b>-0.121**</b> (2,794)	<b>0.026</b> (3,100)	<b>0.062**</b> (1,980)
Masculine Body Build	0.676** (7,423)	1	<b>0.550**</b> (3,766)	<b>0.062**</b> (3,255)	<b>0.206**</b> (3,201)	<b>0.398**</b> (2,468)	<b>0.327**</b> (2,812)	<b>0.149**</b> (2,813)	<b>-0.098**</b> (2,802)	<b>0.029</b> (3,108)	<b>0.065**</b> (1,987)
Physical Strength	0.194** (7,447)	0.158** (7,436)	1	<b>0.052**</b> (3,273)	<b>0.215**</b> (3,216)	<b>0.563**</b> (2,478)	<b>0.390**</b> (2,822)	<b>0.102**</b> (2,823)	<b>-0.123**</b> (2,812)	<b>0.007</b> (3,125)	<b>0.049**</b> (2,001)
Height in inches	0.087** (6,394)	0.089** (6,384)	0.096** (6,629)	1	<b>0.131**</b> (2,738)	<b>0.036</b> (2,381)	<b>0.039</b> (2,375)	<b>0.005</b> (2,376)	<b>-0.014</b> (2,364)	<b>-0.134**</b> (2,707)	<b>-0.076**</b> (1,949)
Low-Deep Voice	0.314** (6,332)	0.284** (6,321)	0.144** (6,528)	0.087** (5,496)	1	<b>0.184**</b> (2,470)	<b>0.152**</b> (2,815)	<b>0.149**</b> (2,816)	<b>0.012</b> (2,806)	<b>0.014</b> (3,115)	<b>0.058**</b> (1,994)
Upper Body Strength	0.172** (4,814)	0.140** (4,806)	0.476** (5,006)	0.063** (4,844)	0.130** (4,961)	1	<b>0.588**</b> (2,477)	<b>0.288**</b> (2,475)	<b>-0.030</b> (2,463)	<b>0.007</b> (2,408)	<b>0.060*</b> (1,704)
Lower Body Strength	0.170** (5,632)	0.100** (5,624)	0.401** (5,824)	0.083** (4,837)	0.113** (5,783)	0.648** (5,002)	1	<b>0.282**</b> (2,823)	<b>-0.008</b> (2,811)	<b>0.014</b> (2,741)	<b>0.033</b> (1,700)
Body Hair	0.073** (5,607)	0.060** (5,597)	0.049** (5,796)	-0.019 (4,808)	0.086** (5,756)	0.266** (4,969)	0.279** (5,791)	1	<b>0.066**</b> (2,811)	<b>0.058**</b> (2,742)	<b>0.035</b> (1,701)

Facial Acne	0.080** (5,592)	0.046** (5,585)	-0.026* (5,783)	0.016 (4,796)	0.052** (5,743)	0.082** (4,947)	0.089** (5,772)	0.211** (5,745)	1	-0.015 (2,730)	-0.073** (1,693)
Hair-color	-0.039** (6,153)	-0.021 (6,141)	-0.028* (6,382)	-0.075** (5,489)	0.022 (6,331)	-0.035* (4,858)	-0.040* (5,663)	0.081** (5,636)	-0.028* (5,622)	1	0.440** (1,998)
Eye-color	-0.023 (3,739)	0.001 (3,731)	-0.008 (3,871)	-0.085** (3,824)	0.017 (3,847)	-0.014 (3,298)	-0.010 (3,297)	0.052** (3,277)	-0.017 (3,267)	0.442** (3,880)	1

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$

**Table 3(a).** Factor Loadings for Androgen-Promoted Traits for Males.

Items	Factor 1	Factor 2	Factor 3	Factor 4
Masculine Mannerism	<b>0.806</b>	-0.001	-0.125	0.056
Masculine Body Build	<b>0.845</b>	0.011	-0.064	0.071
Height	0.002	-0.158	-0.145	<b>0.835</b>
Low Deep Voice	0.178	0.157	0.290	<b>0.633</b>
Overall Physical Strength	<b>0.780</b>	0.059	0.043	0.082
Upper Body Strength	<b>0.679</b>	0.046	0.445	0.026
Lower Body Strength	<b>0.592</b>	0.023	0.481	0.028
Body Hair	0.172	0.081	<b>0.692</b>	0.066
Facial Acne	-0.263	-0.154	<b>0.566</b>	-0.022
Hair Color	0.004	<b>0.832</b>	0.018	-0.064
Eye Color	0.046	<b>0.829</b>	-0.042	0.036

**Table 3(b).** Factor Loadings for Androgen-Promoted Traits for Females.

Items	Factor 1	Factor 2	Factor 3	Factor 4
Masculine Mannerism	0.091	<b>0.856</b>	-0.057	0.050
Masculine Body Build	0.025	<b>0.860</b>	-0.015	0.000
Height	0.132	0.206	-0.212	-0.254
Low Deep Voice	0.119	<b>0.589</b>	0.063	0.017
Overall Physical Strength	<b>0.746</b>	0.164	-0.012	-0.216
Upper Body Strength	<b>0.858</b>	0.096	-0.024	0.134
Lower Body Strength	<b>0.825</b>	0.047	-0.013	0.195
Body Hair	0.299	0.017	0.123	<b>0.677</b>
Facial Acne	-0.054	0.101	-0.121	<b>0.775</b>
Hair Color	0.004	0.002	<b>0.835</b>	0.009
Eye Color	-0.010	0.028	<b>0.830</b>	0.003

to be learned about which androgens are involved in particular traits and when they have their greatest influences. The present study sheds light on the process by suggesting that in both sexes, four independent factors emerge when eleven androgen-promoted physiological traits are measured. The structures of these four factors are slightly different for males and for females.

In males, the primary factor loads most heavily on masculinity and strength, whereas in females, the load-

ing is strictly on strength. We hypothesize that in both sexes this primary factor is the result of perinatal and postpubertal exposure to testosterone. This hypothesis is consistent with studies showing that testosterone is by far the most consequential sex hormone regarding both masculine mannerisms [46] and muscular strength [15, 41]. To explain why mannerisms in females would not be masculinized by testosterone, we suspect that the levels of this hormone to which most females are exposed

are insufficient to significantly affect this trait while muscular strength responds to even low amounts of testosterone. Another possibility is that high (female-typical) exposure to estradiol or other female hormones may counteract the effects of testosterone on masculine mannerisms.

The fact that the same factors for the dark pigmentation factor and the skin-hair factor emerged in both sexes suggests that these traits are a) the result of androgens other than testosterone, and b) that the androgen(s) primarily responsible for hair growth and facial acne is different from those influencing hair and eye color.

Regarding the three questions posed in the introduction, one can conclude the following: First, all eleven traits that other studies have shown to be androgen-promoted are, as expected, more pronounced in males than in females. Second, within each sex, most of the eleven traits are positively correlated. The fact that there are exceptions leads one to expect that different androgens are operating in somewhat different ways within each sex. Third, factor analysis supports this expectation by demonstrating that there are four clusters of androgen-promoted traits amongst the eleven traits examined in the present study. We named these four factors and hypothesized that testosterone is responsible for the first (and most prominent) factor for both sexes. In males, this primary factor involved both strength and masculine mannerisms, while in females it only involved strength.

Research is needed to verify these four factors and to look for other androgen-promoted traits within each sex. In future studies, direct measurement would almost certainly provide more reliable data than self-reports. However, the time required for obtaining direct measures with a sufficiently large sample of subjects needed for factor analysis could be prohibitive. It can also be said that the extent to which people can provide accurate information about themselves may surpass expectations. In this regard, we compared the average heights of our subjects to estimates recently given by the Center for Disease Control based on direct measurements [48]. The results were very similar: 70.88 inches or 5'9.1" tall in our male sample compared to 5'9.2" for the national sample, and 65.15 inches or 5'4.3" tall in our female sample compared to 5'3.8" for the national sample.

If the four factor structure of androgen-promoted traits revealed in the present study can be replicated, the next phase in this line of research would be to identify each of their specific causes. In other words, what are the actual androgens involved in producing each factor and what is the developmental timing involved?

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