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Population differences in androgen levels: A test of the Differential *K* theory

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ABSTRACT

Differential-*K* theory proposes that levels of androgen, i.e. male hormone, differ across three large racial groups with Sub-Saharan Africans having the highest levels, East Asians the lowest, and Caucasians (Europeans, North Africans and South Asians) being intermediate. In this study, we found that most of the national-level indicators of androgen – CAG repeats on the AR gene, androgenic hair, prostate cancer incidence, sex frequency and number of sex partners – are positively correlated at the population (country) level. East Asians showed signs of the lowest androgen level for most indicators and were lower than Caucasians on all of them. Sub-Saharan Africans showed inconsistent results. The results provide a partial validation of Differential-*K* theory.

1. Introduction

Life history (LH) theory is a mid-level evolutionary account of differences in evolved reproductive strategies (Wilson, 1975). LH theory allows the categorization of species along a continuum ranging from fast to slow reproductive strategies. A fast LH strategy is characterized by having large numbers of offspring, but providing relatively little parental care. It tends to be observed in unstable ecologies in which it is beneficial to produce many offspring in order to ensure that at least some survive the relatively unpredictable dangers, such as pathogens and predators, which lead to high mortality rates (Ellis, Figueredo, Brumbach, & Schlomer, 2009). Slow LH strategists have smaller numbers of offspring, but provide relatively high levels of parental care. They also tend to mature more slowly and live longer than fast LH strategists. A slow LH strategy tends to be observed in more stable ecologies. Due to this stability, the environment's maximum carrying capacity for the species is reached and its members begin to compete with each other. They do this by investing less energy in reproduction and more energy in the competitive advantage of their offspring.

Although LH theory was initially developed to account for differences in reproductive strategies between species, it may also account for differences *within* species (Figueredo et al., 2006; Rushton, 2000). For example, all humans adopt a relatively slow LH strategy. Nevertheless, it has been suggested and shown that some individuals tend more towards a faster LH strategy whereas others tend towards a slower LH strategy. This theory is also referred to as Differential-*K* theory (Rushton, 1985), as *K* stands for the 'carrying capacity' of the environment and is often used to indicate a slow LH strategy (in LH theory, the letter *r* stands for reproduction rate and is often used to denote a fast LH strategy).

Differential-*K* theory has been proposed to play a highly relevant role in research on individual differences because it is posited that LH strategy is associated with a wide range of psychological characteristics, such as intelligence, personality, sexual behavior and attitudes, short-term versus long-term planning, and social complexity (Figueredo et al., 2006; Figueredo, Cabeza de Baca, & Woodley, 2013; Hill & Kaplan, 1999). Moreover, it has been proposed that systematic differences in LH strategies may also exist at the population level. Specifically, based on LH strategy, a distinction can be made between three large racial groups namely, (i) East Asians, (ii) Europeans, South Asians and North Africans, and (iii) Sub-Saharan Africans. Henceforward, we refer to these groups as East Asians, Caucasians, and Sub-Saharan Africans, respectively.

East Asians are assumed to tend towards a slower LH strategy, whereas sub-Saharan Africans, on average, tend towards a faster LH strategy. Caucasians fall intermediate between the two. The distinction between these three racial groups, based on LH strategy, has been the topic of much debate and controversy (e.g. Weizmann, Wiener, Wiesenthal, & Ziegler, 1990; Rushton, 2000). However, a large number of studies have confirmed that there exist population differences in LH strategy and have provided evidence that they are likely partly genetic

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(e.g. Meisenberg & Woodley, 2013; Minkov & Bond, 2015; Minkov, 2014).

Although there is a wide range of potential variables that can be used to test group differences in LH strategy (see Rushton, 2000), it has been argued that androgen level is a key variable and may be considered one of the proverbial 'master switches' in regulating LH strategy. Specifically, in humans, slower LH strategies are posited to be accompanied by lower androgen levels. Indeed, it was proposed by Lynn (1990) that there were racial differences in androgen levels, such that these are highest in Sub-Saharan Africans, followed by Caucasians and lowest in East Asians, and these were a determinant of racial differences in LH strategy. One of the presumed reasons for such adaptation is that harsh, but predictable environments required more cooperation between males, for instance in hunting, and more stable bonds between parents. The need for increased cooperation, decreased inter-male competition and stronger pair-bonding in colder northern environments has been suggested to have led to lowered androgen levels (Miller, 1994). Androgen has a behavioral and physiological impact including increasing aggression and competitiveness (Dabbs & Dabbs, 2000), the amount of hair on the body (androgenic hair: Hindley & Damon, 1973), the primary sexual characteristics (Baskin et al., 1997), and the vulnerability to certain types of diseases (Gann, Hennekens, Ma, Longcope, & Stampfer, 1996).

There has been considerable research on group differences and many of these studies have reported findings that were in line with the predictions derived from Differential-*K* theory (e.g. Meisenberg & Woodley, 2013 or Minkov & Bond, 2015). However, there are relatively few studies that have tested the androgen hypothesis: that Sub-Saharan Africans should have the highest levels of androgen, followed by Caucasians, who are expected to have higher androgen levels than East Asians.

The present study seeks to contribute to this research area by further examining the androgen hypothesis, using a wider range of androgen indicators than previous studies. Specifically, in testing whether there are group differences in androgen we consider country level anthropological and medical data including the amount of body hair, prostate cancer incidence, behavioral data (sex frequency and number of sex partners), and genetic data (alleles related to androgen sensitivity). The rationale for this approach is that although each of these individual data sources may also have a certain level of error, combining them into a single study would lead to stronger conclusions when the various indicators point to the same direction.

2. Method

We collected a range of national-level indicators of androgen levels. Inclusion criteria for the indicators were that there is evidence that the indicator relates to androgen levels, and that there are estimates for different countries on the indicator. For some indicators, data were available from a large number of countries, for other indicators however, data were available for only a limited number of countries. Therefore, in the analyses we provide the *N* or degrees of freedom (*DF*) for each test.

2.1 Androgen indicators.

2.1.1 CAG repeats in AR gene

Minkov and Bond (2015) tested national differences in LH strategy using genetic polymorphisms. As part of their study they collected national-level data on the AR gene, which is a known androgen receptor gene that is polymorphic. Higher numbers of CAG repeats (i.e longer CAGs) have been linked to higher insensitivity to testosterone (Manning, Bundred, Newton, & Flanagan, 2003). There are several studies showing positive relations between shorter CAG and more sexual partners, and violent and impulsive behavior (see Minkov & Bond, 2015 for a review of literature). CAG length of the AR gene was obtained for $N = 50$ countries. In some cases, individual countries were estimated by Minkov and Bond based on combining data for neighboring countries. They also used West African data to estimate other Sub-Saharan African countries. But, in general, they drew upon primary data from other studies.

2.1.2 Androgenic hair

The level of androgenic hair indicates higher androgen levels and mid-phalangeal hair (hair on the middle digit or the [ring] finger) is a proxy for androgenic hair. A number of meta-analyses have brought together the available data on the average level of mid-phalangeal hair in certain countries (Hindley & Damon, 1973; Westlund, Oinonen, Mazmanian, & Bird, 2015). We drew upon these data and used them to estimate values for neighboring and near-neighboring countries based on genetic assay data and proximity. This gave us 124 countries, though none from South America nor southern nor central Africa. In certain other cases, of countries which are clines (e.g. Uzbekistan), it was not possible to derive an estimate.

2.1.3 Prostate cancer incidence

Androgens contribute to the risk of developing prostate cancer (Lynn, 1990; Gann et al., 1996). We used the most detailed international prostate cancer incidence numbers we could find, namely those reported in Haas, Delongchamps, Brawley, Wang, and de la Roza (2008). In this study, incidence rates are reported for 32 countries.

2.1.4 Sexual behavior

Libido is strongly influenced by androgens (Bancroft, 2005) and sexual behavior partly reflects libido. There is a large study on this topic conducted by Durex, a company that produces condoms worldwide (Durex, 2005). This study included measures of the annual frequency of sex and the number of sex partners. The study contains data on 41 countries from different continents, though only one African sample. 317,000 people from these 41 countries filled in the survey. The mean annual sex frequency was 103.15, but large variation exists between countries ($SD = 17.72$). The countries employed in this study for each measure can be seen in Table 1.

2.2 Group classification

To test the androgen hypothesis, we constructed three categories based on the main population within a country. Specifically, Northeast Asian (e.g. China) and Southeast Asian (e.g. Malaysia), countries were classified as East Asian. All European countries, North African and several South-Asian countries (e.g., India) were categorized as Caucasian. Sub-Saharan countries were classified as Sub-Saharan African. Although some countries' populations are more ethnically mixed than others, this kind of issue exists with any system of classification. The groups have been shown to consistently genetically vary (e.g. Cavalli-Sforza, Menozzi, & Piazza, 1994).

3. Results

Table 2 shows that 7 out of the 10 possible correlations between the different androgen indicators were significant and in the expected direction. For example, shorter CAG length was significantly associated with higher annual sex frequency. Prostate cancer incidence was not significantly related to CAG-length, although it has to be noted that the correlation of the CAG length–prostate cancer association was still substantial ($r = -.32$). The second correlation not reaching significance was between CAG-length and number of sexual partners, but this correlation also showed a relatively large effect size ($r = -.30$) and was non-significant at the .05 level, but almost reached significance ($p = .06$). The correlation between CAG length and androgenic hair was not significant and the effect size was weak.

Table 3 shows the results of the ANOVAs comparing the three large groups on the androgen indicators. Post-hoc testing showed that countries with mainly East Asian populations had significantly longer CAGs

Table 1
Country samples drawn upon for each measure and racial classification for each country.

Country	Race	Measures				
		CAG	Mid-phalangeal hair (MPH)	MPH-reference	Pr. cancer	Sex freq/partners
Afghanistan	C		X			
Albania	C		X			
Algeria	C	X	X			
Angola	A					
Armenia	A		X	Westlund et al.	X	
Australia	C	X	X		X	X
Austria	C	X	X			X
Azerbaijan	C		X			
Bahrain	C		X			
Bangladesh	C		X			
Barbados	A	X				
Belarus	C		X			X
Belgium	C	X	X			
Benin	A		X			
Bhutan	–		X			
Bosnia	C		X			
Botswana	A	X				
Brunei	C		X			
Bulgaria	C		X			X
Burkina Faso	A		X			
Cambodia	E		X			
Cameroon	A		X			
Canada	C	X	X		X	X
Chad	A		X			
Chile	C	X				X
Congo	A				X	
China	E	X	X	Westlund et al.	X	X
Cote d'Ivoire	A	X	X			
Croatia	C		X			X
Cyprus	C		X			
Czech Republic	C		X			X
Denmark	C	X	X			X
Djibouti	A		X			
Egypt	C	X	X	Westlund et al		
Eritrea	A		X			
Estonia	C	X	X			
Ethiopia	A		X	Hindley & Damon		
Finland	C	X	X			X
France	C		X		X	X
Gabon	A		X			
Gambia	A		X			
Georgia	C		X	Westlund et al.		
Germany	C	X	X	Westlund et al		X
Ghana	A	X	X	Westlund et al.		
Greece	C	X	X			X
Guinea			X			
Guinea-Bissau			X			
Haiti	A		X			
Hong Kong	E	X	X			X
Hungary	C	X	X		X	
Iceland	C		X		X	X
India	C	X	X	Westlund et al		X
Indonesia	E	X	X			X
Iran	C	X	X			
Iraq	C		X	Westlund et al		
Ireland	C	X	X			X
Israel	C	X	X	Westlund et al	X	X
Italy	C	X	X			X
Jamaica	A		X			
Japan	E	X	X	Westlund et al		X
Jordan	C	X	X			
Kazakhstan			X			
Kenya	A		X		X	
Kuwait	C		X			
Kyrgyzstan			X			
Laos	E		X			
Latvia	C	X	X			
Lebanon	C		X			
Liberia	A		X			
Libya	C		X			
Liechtenstein	C		X			
Lithuania	C		X			

(continued on next page)

Table 1 (*continued*)

Country	Race	Measures				
		CAG	Mid-phalangeal hair (MPH)	MPH-reference	Pr. cancer	Sex freq/partners
Luxembourg	C		X			
Macedonia	C	X	X			
Malaysia	E	X	X	Westlund et al.		X
Mali	A		X			
Malta	C		X			
Moldova	C		X			
Mongolia	E		X			
Montenegro	C		X			
Morocco	C	X	X			
Myanmar/Burma	E		X			
Nepal	E		X	Hindley & Damon		
Netherlands	C	X	X	Westlund et al		X
New Zealand	C	X	X		X	X
Niger	A		X			
Nigeria	A		X	Westlund et al.		
North Korea	E		X			
Northern Ireland	C		X			
Norway	C	X	X		X	X
Oman	C		X			
Pakistan	C		X			
Palestine	C		X			
Philippines	E		X			
Poland	C	X	X			X
Portugal	C		X			X
Qatar	C		X			
Romania	C		X			
Russia	C	X	X	Westlund et al		
Saudi Arabia	C	X	X			
Senegal	A		X		X	
Serbia	C		X	Hindley & Damon		
Sierra Leone	A		X			
Singapore	E	X	X			X
Slovakia	C		X			X
Slovenia	C		X			
Somalia	A		X			
South Africa	A	X				
South Korea	E	X	X		X	
Spain	C	X	X	Westlund et al.	X	X
Sri Lanka	C		X			
Sudan	A		X			
Sweden	C	X	X	Saldanha and Guinsburg (1961)	X	X
Switzerland	C		X		X	X
Syria	C		X	Westlund et al.		
Taiwan	E		X		X	X
Tajikistan			X			
Thailand	E	X	X		X	
Togo	A		X			
Trinidad & Tobago	A		X			
Tunisia	C		X			
Turkey	C	X	X			X
Turkmenistan	C		X			
Uganda					X	
Ukraine	C	X	X			
United Arab Emirates	C		X			
United Kingdom	C		X		X	X
United States	C		X	Westlund et al		X
United States	A		X	Westlund et al	X	
Vietnam	E	X	X			X
Yemen	C	X	X			
Zimbabwe					X	

Note: race: A = Sub-Saharan African, C = Caucasian, E = East Asian.

Table 2
Correlations (and N) between the androgen indicators at the national level.

	1	2	3	4	5
1. CAG length	–				
2. Androgenic hair	.14 (*43*)	–			
3. Prostate cancer	−.32 (*14*)	.82** (*25*)	–		
4. Sex frequency	−.58** (*28*)	.55** (*38*)	.46* (*18*)	–	
5. # sex partners	−.30 (*28*)	.52** (*38*)	.58** (*18*)	.32* (*41*)	–

* $p < .05$.
** $p < .01$.

than the other two groups. The difference between countries with mainly Caucasian populations and countries with mainly Sub-Saharan African populations did not reach significance although it was in the expected direction.

For annual sex frequency and number of sexual partners we were able to compare only East Asians with Caucasians. Nevertheless, findings in these analyses were also in line with the androgen hypothesis, with Caucasians scoring significantly higher on these measures. As such, on 3/5 of the measures East Asians had the lowest levels of

Table 3
Group comparisons (ANOVAs and Tukey's HSD post-hoc tests) of the androgen indicators.

	East Asians	Caucasians	Sub-Saharan Africans				
	M (+SD)	M (+SD)	M (+SD)	F	DF	P	Post-hoc
CAG-length	23.10 (*0.35*)	21.31 (*1.28*)	20.20 (*0.93*)	11.16	2, 33	<.001	b
N	8	24	4				
Androgenic hair	38.71 (*5.72*)	62.49 (*10.04*)	13.63 (*7.69*)	87.85	2, 104	<.001	c
N	14	71	22				
Prostate cancer	5.40 (*4.90*)	64.40 (*19.36*)	16.88 (*10.41*)	41.26	2, 23	<.001	c
N	4	10	12				
Sex frequency	80.75 (*16.67*)	107.18 (*11.95*)	A	23.22	2, 28	<.001	
N	8	22					
Sex partners	6.48 (*2.83*)	9.21 (*2.81*)	A	5.53	2, 28	.03	
N	8	22					

Notes: a = no data on these variables was available for Sub-Saharan countries; b = East Asians significantly differed from Caucasians and Sub-Saharan Africans, c = Caucasians significantly differed from East Asians and Sub-Saharan Africans.

androgen compared to the other two groups and they were significantly lower than those of Caucasians on all measures.

Two of the indicators showed results that were only partly in line with the androgen hypothesis. First, Caucasians had significantly more androgenic hair than the two other groups. Second, Caucasians had a significantly higher prostate cancer incidence than the other two groups, who did not significantly differ from each other.

4. Discussion

The present study used five national-level variables to test the androgen hypothesis derived from the Differential-*K* theory. These variables provide a more extensive test of this hypothesis than has been available hitherto. Although the variables widely differed in nature (i.e., behavioral data, survey responses, physiological measures) and were extracted from various sources (i.e., medical, anthropological, and psychological literature), overall they showed substantial and meaningful inter-correlations, supporting the hypothesis that they are indeed manifestations of androgen levels.

On all five variables, the averages of East Asian countries were significantly different from those of Caucasian countries. This supports the hypothesis that East Asians, on average, have lower androgen levels which is in line with the notion that they may tend to adopt a slower LH strategy as indicated in previous studies.

Regarding Sub-Saharan Africans, two variables, namely sex frequency and number of sex partners, did not allow comparisons with the other groups as no African country was included so no support for the hypothesis may be gleaned from these. The CAG-repeat length of the AR gene showed the predicted pattern (see Table 3). However, the Caucasian–Sub-Saharan African difference did not reach significance, so it did not support the hypothesis. It can be seen from the scatter diagrams (Figs. 1 and 2) that the associations we have found were not caused by outliers.

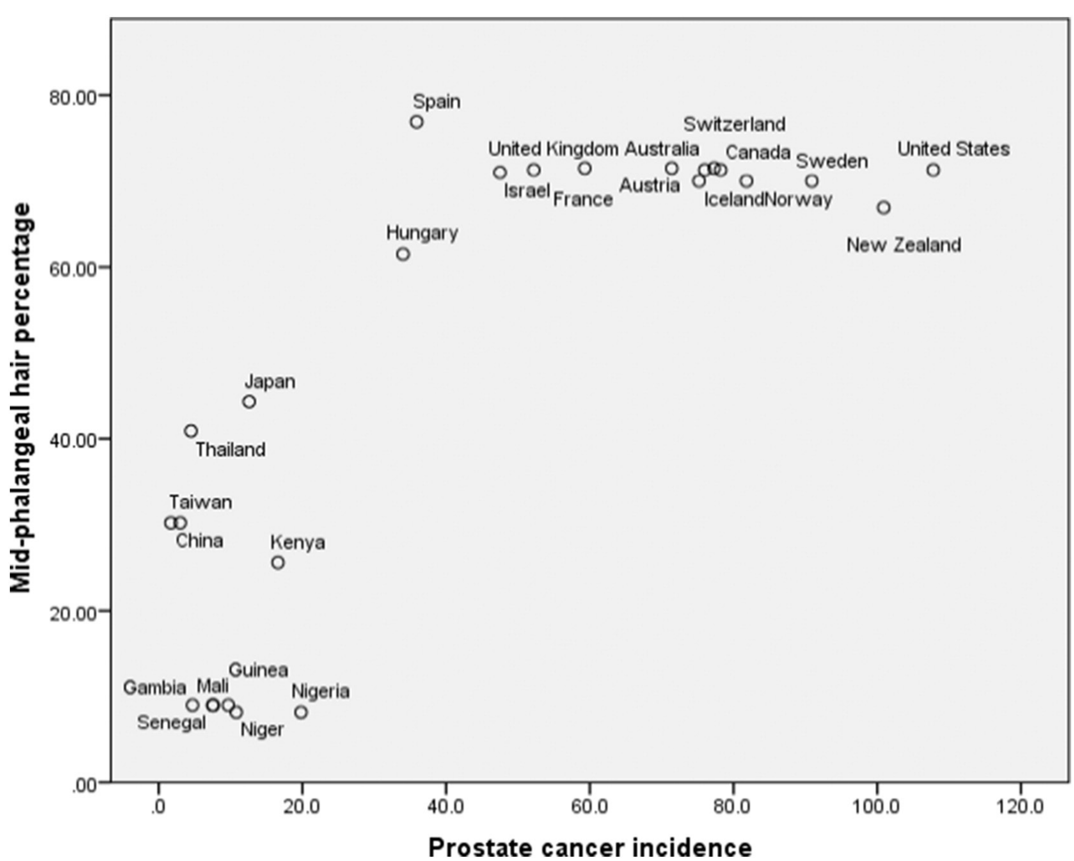

Fig. 1. Relationship between androgenic hair percentage (mid-phalangeal hair) and prostate cancer incidence.

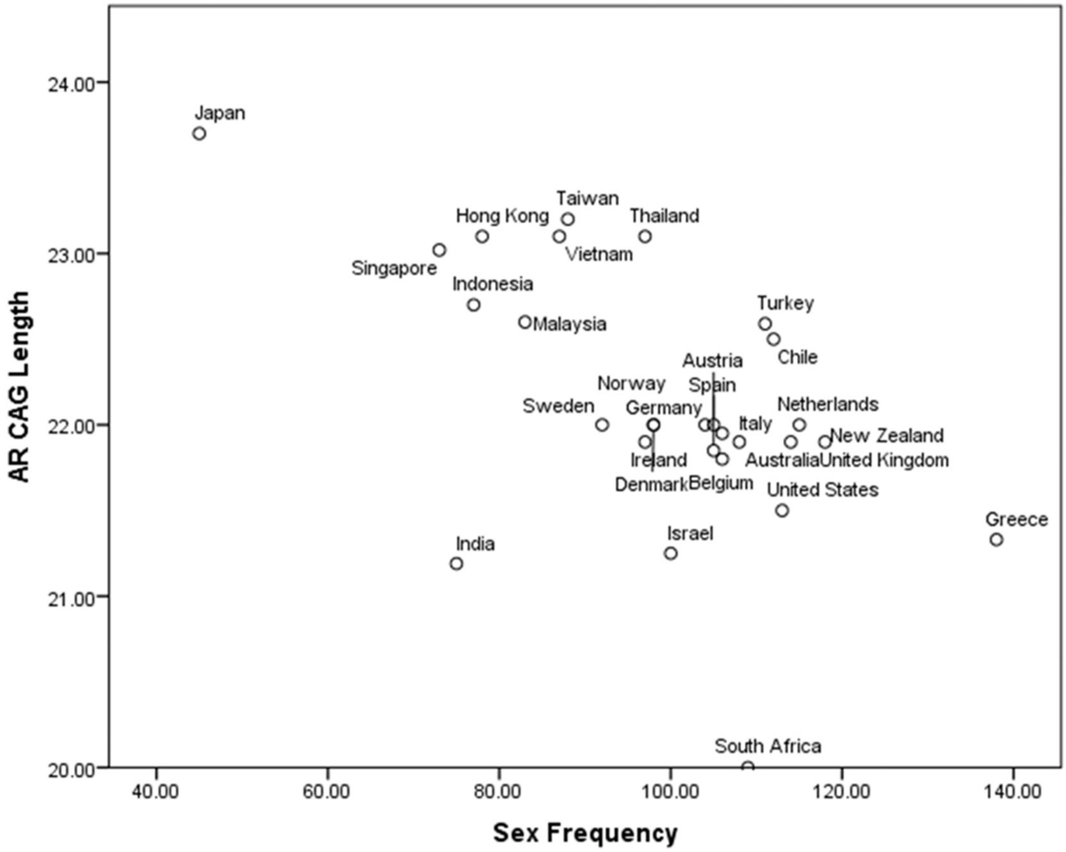

Fig. 2. Relationship between CAG-repeat length of the AR gene and sex frequency.

The data on androgenic hair and prostate cancer incidence did not support the androgen hypothesis. Compared with Caucasians, Sub-Saharan Africans had significantly less prostate cancer incidence and significantly less androgenic hair. The prostate cancer anomaly is likely explicable in terms of differences in general diet. For example, those in Western or more industrialized countries consume more dairy products than those in African countries on average. Dairy consumption has been shown to increase prostate cancer risk (e.g. Chan et al., 2001) as has obesity (Calle, Rodriguez, Walker-Thurmond, & Thun, 2003), another Western lifestyle factor. The notion that the major differences between Western countries and African countries may be related to diet is supported by the fact that, for example, within the USA, African Americans have 30% higher risk of developing prostate cancer than whites (Landis, Murray, Bolden, & Wingo, 1999). Asians living in the USA have the lowest prevalence in prostate cancer (McIntosh, 1997). According to 2010 data 70% of African American men over the age over 20 and 73.6% of white American men over the age of 20 are classified as overweight or obese, using age-adjusted data. For overweight but not obese these figures are 38.7% and 41.1% respectively, while for obese they are 38.3% and 34.1% (Office for Minority Health, 2012). Thus, despite relatively similar levels of obesity, African Americans are more likely to develop prostate cancer than whites. Accordingly, it would seem that when environmental factors that affect prostate cancer are controlled the predicted race differences are found, though it should be remembered that differences in other factors, such as access to medical care, may also impact these results. Evidence found that African American men in the United Sates have a 15% higher level of freely circulating testosterone and that this contributes to their higher rate of prostate cancer has been presented by Ross, et al. (1986). That said, it should also be remembered that African Americans are primarily from certain areas of West Africa and thus may not be fully representative of current Sub-Saharan Africans.

The anomaly that Caucasians have the highest levels of androgenic hair and Africans the lowest can only be speculated upon. It has been found that Caucasians, in contrast to the other two populations, retain a small percentage (2–4%) of Neanderthal genes. It has been argued that this may be one of the reasons why Caucasians are unexpectedly hairy (e.g. Sankararaman, et al., 2014). In addition, Westlund et al. (2015) have suggested that presumably low MPH–high androgen groups (e.g. African Americans) may have high levels of the hormone DHT in their middle-phalangeal hair follicles as well as low levels of MPH for reasons similar to those underlying evidence of increased DHT in scalp hair follicles of individuals with male pattern baldness.

It should also be noted that another line of research on this topic involves the 2D:4D finger index ratio, which is the ratio between the length of the index and the ring finger. Many studies have confirmed that the 2D:4D ratio reflects in utero exposure to androgen (i.e., testosterone; see Manning, 2002 for a review). Higher ratios indicate less androgen exposure. The 2D:4D index has been linked to a wide range of behaviors and physiological characteristics that are known to be influenced by androgen. We did not include 2D:4D ratio studies in our study due to the simple fact that no large studies were available that directly compared enough countries on this measure. However, at least one study has directly reported an index ratio order in which East Asians (Han Chinese) had the highest ratio, followed by Caucasians (Berbers, Uygurs), followed by Afro-Caribbean individuals in Jamaica (Manning, Stewart, Bundred, & Trivers, 2004).[1]

[1] It has to be noted that the literature shows that 2D:4D ratio does not relate significantly to all other androgen indicators we used in this study. For example, a recent review of Loehlin, Medland, and Martin (2011) and a meta-analysis of Honekopp (2013) suggest that 2D:4D is not significantly related to CAG length. On the other hand, the literature also shows that CAG length is relatively inconsistently related to other androgen indicators in general. Thus, the fact that CAG-length generally does not relate to the 2D:4D ratio does not compromise the validity of the latter as a marker of prenatal androgen exposure.

5. Limitations

Differential *K* theory describes how individual differences in evolved reproductive strategies may lie at the heart of differential psychology and may also partly explain group differences. A wide range of studies have confirmed several of its major predictions, but, as stated above, with regard to the androgen hypothesis, relatively little empirical work exists. The present study built on that previous work by showing that group differences exists on a wide range of androgen indicators. The findings provide a partial confirmation of Differential *K* theory and where its findings are not congruous with it these can be explained relatively simply.

Clearly, there are limitations to this study. It has been necessary to draw upon secondary sources to acquire data, these sources mostly do not provide us with the *N* per nation, not all of the datasets compare all of the racial groups, one of the datasets (Durex) has not been peer-reviewed, two of the datasets (CAG and Androgenic Hair) include estimations extrapolated from neighboring or racially similar countries, and each is only a partial measure of testosterone. Environmental factors, such as diet and living conditions may partly play a role, but given the fundamental nature of several indicators (e.g., CAG length, body hair) we consider it unlikely that our results can solely be caused by such factors. Instead, we consider it more likely that the differences in androgen levels are one of the manifestations of a larger suite of characteristics indicative for a slow versus fast LH strategy (Minkov & Bond, 2015; Figueredo et al., 2005).

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