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Sex and ethnic differences in 2nd to 4th digit ratio of children

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Abstract

Background: The ratio between the length of the 2nd or index finger and the 4th or ring finger (2D:4D) differs between the sexes, such that males have lower 2D:4D than females, and shows considerable ethnic differences, with low values found in Black populations. It has been suggested that the sex difference in 2D:4D arises early in development and that finger ratio is a correlate of prenatal testosterone and oestrogen. In children, 2D:4D has been reported to be associated with measures of fetal growth, congenital adrenal hyperplasia, developmental psychopathology, autism and Asperger's syndrome. However, little is known of the patterns of sex and ethnic differences in the 2D:4D ratio of children.
Aim: To investigate sex and ethnic differences in 2D:4D in Caucasian, Oriental and Black children.
Study design: Population survey.
Method: The 2D:4D ratio was measured from photocopies of the right hand of Berber children from Morocco, Uygur and Han children from the North-West province of China, and children from Jamaica.
Results: There were 798 children in the total sample (90 Berbers, 438 Uygurs, 118 Han, and 152 Jamaicans). The 2D:4D ratio was lower in males than in females and this was significant for the overall sample and for the Uygur, Han and Jamaican samples. There were significant ethnic differences in 2D:4D. The Oriental Han had the highest mean 2D:4D, followed by the Caucasian Berbers and Uygurs, with the lowest mean ratios found in the Afro-Caribbean

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Jamaicans. The sex and ethnic differences were independent of one another with no significant interaction effect. In the overall sample there were no associations between 2D:4D and age and height.

Conclusions: In common with adults, the 2D:4D ratio of children shows sex and ethnic differences with low values found in a Black group. There was no overall association between 2D:4D and age and height suggesting that the sex and ethnic differences in 2D:4D appear early and do not show appreciable change with growth.

Keywords: 2D:4D; Children; Sex and ethnic differences

The ratio between the length of the 2nd or index finger and the 4th or ring finger (2D:4D) shows sex differences such that males tend to have lower values of 2D:4D, i.e. longer 4th digits relative to 2nd, than females. This sex difference may arise through a common developmental link between the formation of the urinogenital system and the fingers [1]. Loss-of-function mutations of groups of Homeobox (*hox*) genes (*hoxa* and *hoxd*) lead to sterility and malformations of the fingers [2]. The nature of this association between the fetal reproductive system and the fingers may be in the production of sex steroids by the fetal gonads. Thus, it has been suggested that the 2D:4D ratio is fixed early in development and is negatively related to fetal testosterone and positively related to fetal oestrogen [1].

A link between early sex steroids and 2D:4D in mammals is supported by the following observations: (a) the sex difference in adult 2D:4D is found in children as young as 2 years, it is robust across ethnic groups, but there are also ethnic differences in 2D:4D which are independent of sex and may result from between-population variation in fetal sex hormones [3,4], (b) sexual dimorphism in 2D:4D is also found in mice and the sex differences are similar to those of humans [5,6], (c) in humans, low 2D:4D is positively correlated with birth weight and head circumference but in males only [7], (d) some developmental disorders which are more common in boys (autism and Asperger's syndrome) are related to low values of 2D:4D [8], (e) childhood behaviours which are thought to be related to prenatal testosterone (hyperactivity and poor social cognition) are associated with low 2D:4D [9], (f) high waist-to-hip ratio in mothers (a correlate of high testosterone) is correlated with low 2D:4D ratio in their children [10], (g) children with congenital adrenal hyperplasia, a trait associated with high fetal androgen, have low 2D:4D ratios compared to healthy controls [11,12] and (h) high sensitivity to testosterone, as measured from the structure of the androgen receptor gene, is related to low 2D:4D [13,14].

If 2D:4D is a correlate of prenatal testosterone and oestrogen then it must follow that much of the variance in finger ratio is determined in utero. This means that children should show patterns of 2D:4D which are essentially the same as those found in adults. A cross-sectional study of 2D:4D in Caucasian English children and adults found that finger ratio showed sex differences as early as age 2 years and there was no evidence of a change of ratio at puberty [1,15]. This was in marked contrast to most sexually dimorphic traits, such as waist-to-hip ratio, which show minimal dimorphism in children and marked sex differences that arise at puberty [15]. A sex difference in 2D:4D with lower values in males compared to females, was also found in a sample of Scottish children aged 2 to 5 years [9]. However, in this cross-sectional sample there was some evidence of a weak tendency for 2D:4D to increase with age, suggesting that the finger ratio may be modified during periods of rapid growth. The purpose of this work is to present measures of 2D:4D from Caucasian, Oriental and Black populations. Specifically we ask whether: (a) 2D:4D in children is sexually dimorphic across ethnic groups, (b) children's 2D:4D shows ethnic differences which are independent of sex and (c) there is evidence that 2D:4D in children remains stable across age and height groups.

1. Method

The local ethics committees approved the study and parents/guardians provided written consent. The age of the participants was recorded and their height measured. Images of the right hand were obtained by photocopying the ventral surface of the hand. We excluded subjects with injuries to the 2nd or the 4th fingers. All photocopies were checked to establish whether the creases at the base of the finger were clearly visible, if not the photocopy was taken again. Measurements of the fingers were from a mid-point of the flexure-crease proximal to the palm to the tip of the finger and were made with vernier callipers measuring to 0.01 mm. These soft tissue measurements of the fingers correlate with those taken from X-rays of the bones of the fingers [15], and it is known that finger measurements and 2D:4D ratios measured directly from the hand and from photocopies are very similar and show high repeatabilities [3]. In order to establish the repeatability of measurements taken from the photocopies, 120 hands were measured twice, i.e. 30 hands in each of the four samples.

Our sample populations included two Caucasian (the Berbers of Morocco and the Uygur of the North-West Province of China), one Oriental (Han of the North-West Province of China) and one Afro-Caribbean (rural Jamaican children). The Berber sample was recruited from Moroccan schools in the area of Tabatkoukt, which is east of Agadir in the foothills of the Atlas Mountains. The Berbers are a Caucasian people who are thought of as the original inhabitants of North Africa, and who make up about 40% of the present-day population of Morocco [16]. The participants from the North-West Province of China were recruited from schools in the Xinjiang area. They were comprised of Uygur and Han children. The Uygur are a Caucasian people with a language closely related to Turkish and a written script that is Arabic [17]. They are thought to have been derived from the Turks and are the most common ethnic group in the North-West province. The Han are an Oriental group and are the major Chinese race [17]. The Jamaican children were recruited from schools in Southfield in the Parish of St. Elizabeth. This is a rural area in the South of the Island. All the children were Afro-Caribbean and were drawn from among participants in a long-term study of developmental stability (The Jamaican Symmetry Project).

We used the following statistical tests: t-tests, Pearson correlation tests, single factor and two factor ANOVAS, repeated measures ANOVA, simultaneous multiple regression analysis. All p values are two-tailed.

2. Results

2.1. Repeatability of 2D:4D ratios

We calculated the repeatability (r_1) of the 2D:4D ratios by using Model II single factor ANOVA tests:

$$r_1 = (\text{groups MS} - \text{error MS})/(\text{groups MS} + \text{error MS})$$

where MS=mean squares. In addition, repeated measures ANOVA tests were used to calculate the ratio (F) of between-individual differences in 2D:4D to within-individual measurement error:

$$F = (\text{groups MS})/(\text{error MS})$$

In all four samples, the F values showed that the differences in 2D:4D were significantly greater than the error involved in measuring 2D:4D ratio (Berbers r_1=0.90, F=18.72, p=0.0001: Uygurs r_1=0.96, F=46.37, p=0.0001; Han r_1=0.96, F=49.99, p=0.0001; Jamaicans r_1=0.77, F=8.00, p=0.0001). We concluded that our 2D:4D ratios reflected real differences between individuals.

2.2. Descriptive statistics of the sample

In total, the sample comprised 798 children (400 males and 398 females). There were 90 Berber children (54 males and 36 females), 438 Uygur children (209 males and 229 females), and 152 Jamaican children (78 males and 74 females).

The means (S.D.) and ranges of age varied from 10.00 (1.85) years, 6–14 years for the Berber children; 8.95 (1.40) years, 6–14 years for the Uygurs; 7.50 (1.13) years, 6–11 years for the Han; and 7.66 (1.41) years, 5–11 years for the Jamaican children. For height, the means (S.D.) and ranges varied from 131.16 (10.53) cm, 109.5–156.20 cm among the Berbers; 129.54 (8.02) cm, 113.00–154.00 cm for the Uygurs; 125.79 (6.70), 109.50–147.00 cm for the Han; and 128.05 (9.29) cm, 106.68–157.48 cm for the Jamaican children.

2.3. Sex and ethnic differences in 2D:4D ratios

In the overall sample, there was a significant sex difference in 2D:4D with boys showing lower mean values of 2D:4D in comparison to girls (males 0.940±0.038, females 0.951±0.033, t=4.38, p=0.0001). As expected in all four samples, the mean male finger ratios were lower in boys compared to girls. Among the Berber children, this difference was not significant (males 0.945±0.035, females 0.957±0.029, t=1.78, p=0.08). The sex difference was significant among the Uygurs (males 0.940±0.040, females 0.950±0.033, t=2.87, p=0.004), the Han (males 0.94±0.030, females 0.961±0.033, t=2.45, p=0.02) and the Jamaican children (males 0.929±0.037, females 0.941±0.032, t=2.12, p=0.03).

The Han children had the highest mean values of 2D:4D (0.954± −0.032), they were followed by the Berbers (0.950±0.033), then the Uygurs (0.946±0.037), and the

Jamaican children had the lowest mean 2D:4D (0.935±0.035). These differences in mean 2D:4D across the ethnic groups were significant (ANOVA, $F[3,793]=7.54$, $p=0.0001$: Fig. 1).

The sex and ethnic differences in 2D:4D were independent of one another and showed no significant interaction suggesting that sex differences were not dependent on ethnic group (two-factor ANOVA, Sex [A] and ethnicity [B], Sex $F=16.12$, $p=0.0001$, ethnicity $F=7.81$, p=0.0001, AB $F=0.13$, $p=0.94$).

2.4. 2D:4D, age and height

In three of our samples (Berbers, Han and Jamaicans), there was no evidence of relationships between 2D:4D and either age or height (Berbers age $r=0.08$, $p=0.46$, height males $r=-0.1$, $p=0.47$, females $r=-0.17$, $p=0.32$; Han age $r=-0.04$, $p=0.71$, height males $r=-0.07$, $p=0.63$, females $r=-0.13$, $p=0.34$; Jamaicans age $r=0.09$, $p=0.26$, height males $r=-0.007$, $p=0.95$, females $r=0.23$, $p=0.053$).

In the Uygur sample, there were weak but significant negative associations between age and 2D:4D ($r=-0.16$, $p=0.0006$), and 2D:4D and height for females only (males $r=-0.06$, $p=0.38$, females $r=-0.18$, $p=0.008$). This suggested that 2D:4D reduced with age in Uygur children between the age of 6 and 14 years.

Within the overall sample, we examined whether age or height had an effect on 2D:4D by using multiple regression analysis. The dependent variable was 2D:4D. There were six independent variables, they included age and height and four dummy variables. Sex was coded 0=males and females=1. The influence of ethnicity was removed by using three dummy variables, these were Han (=1) and others (=0), Uygur (=1) and others (=0), and Berber (=1) and others (=0). Constructed in this way, the Jamaican children were always in the ‘others’ group for each dummy variable. As age and height were expected to be

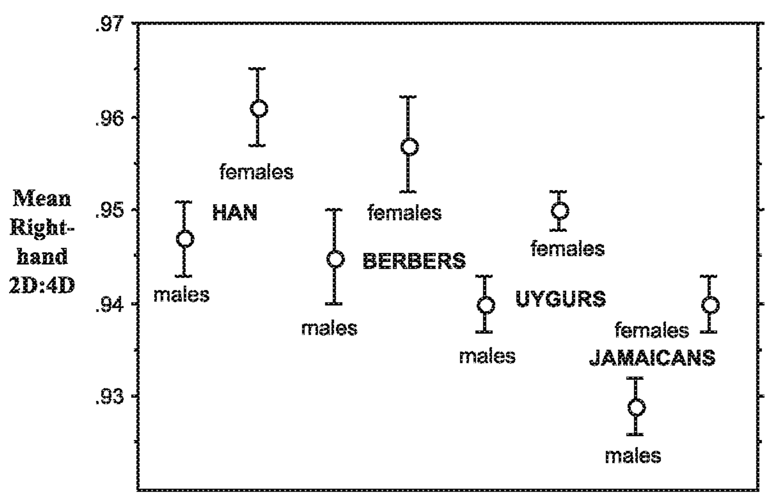

Fig. 1. Mean male and female 2D:4D ratios of the right hand in 118 Han, 90 Berber, 438 Uygur and 152 Jamaican children.

Table 1
The results of a simultaneous multiple regression analysis with 2D:4D of the right hand as the dependent variable and dependent variables, age, height, dummy variable sex (males=0, females=1), and dummy variables for ethnicity (Han=1 others=0; Uygur=1 others=0; Berber=1 others=0)

	Partial *b*	*t*	*p*
Age	−0.0002	0.17	0.87
Height	−0.0002	1.17	0.24
Sex	0.01	4.33	0.0001
Han/others	0.02	4.32	0.0001
Uygur/others	0.01	2.99	0.0001
Berber/others	0.02	3.31	0.0001

strongly related, we used simultaneous multiple regression analysis. The results are shown in Table 1. As can be seen, age (p=0.87) and height (p=0.24) are not significant predictors of 2D:4D. As expected, the dummy variables of sex and ethnicity all show significant positive slopes against 2D:4D. The former confirms that males have lower 2D:4D than females, the latter indicates that the Caucasian and Oriental 2D:4D are higher than the Afro-Caribbean 2D:4D ratios.

3. Discussion

We have the following results (a) in all four samples boys had lower mean 2D:4D than girls, this sex difference was significant for three samples (the Uygurs, Han and Jamaicans), and in the overall sample (b) there were significant ethnic differences in 2D:4D with the lowest mean 2D:4D found in the Afro-Caribbean Jamaican children. The ethnic differences were independent of sex and there were no interaction effects between sex and ethnicity. This suggests that the sexual dimorphism in children's 2D:4D does not vary with ethnicity (c) there was a weak but significant negative association between age and 2D:4D and also for male height and 2D:4D in Uygur children. However, the other groups did not show these significant associations, and in the overall sample age and height did not predict 2D:4D.

These findings support an early appearance of sexual dimorphism in 2D:4D. The age range considered was 5–14 years. However, evidence for sex differences in 2D:4D have been found in English and Scottish children as young as 2 years [1,9]. It appears that sexual dimorphism in the 2D:4D ratio is common in children. It also appears that such dimorphism is widespread in that significant sex differences in 2D:4D have been found in English, Scottish, Uygur, Han and Jamaican children.

Our findings for ethnic differences in 2D:4D among children have similarities to the data available for adults. Thus mean Caucasian finger ratios in children are higher than mean ratios for a Black sample, and this appears to be so for adults [3,4]. One small sample of Caucasian Finnish children has shown a low mean 2D:4D [3]. This suggests that not all Caucasian populations are highly oestrogenized before birth. Therefore, further data are required to confirm that on average Black populations are more androgenized in utero than Caucasian groups. In comparison to our Caucasian and Black groups, we found a Han sample to have quite high ratios. There are as yet no published data for mean Oriental 2D:4D in adults, and we must wait to see how Oriental groups fit into the overall pattern of in utero androgenization. There was no significant interaction between sexual dimorphism of 2D:4D and ethnic differences. This suggests that the nonsignificant sex difference found in Berbers was the result of sampling effects rather than a lack of sexual dimorphism in 2D:4D within the Berber population.

We found that age and height did not predict 2D:4D among our overall sample. Within the sample, the Uygur children showed weak but significant negative slopes when 2D:4D was regressed on age and height (males only). An English sample (aged 2 to 25 years) showed no significant trend when 2D:4D was regressed on age [1] but a positive association between age and 2D:4D was found in a Scottish sample (aged 2 to 5 years). Overall, there appears to be little support for a change in 2D:4D with age in children. However, all data thus far have been cross-sectional. We must wait for cross-cultural longitudinal data to settle this important question.

In conclusion, our data from Berber, Uygur, Han and Jamaican populations support a widespread sexual dimorphism in 2D:4D among children. Ethnic differences in 2D:4D are strong in children as they are in adults, with low ratios in Black populations, and our data on age and height do not support a change in 2D:4D with growth.

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