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LETTER TO THE EDITOR

Latitudinal Gradient in 2D:4D

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The potential dependence of second-to-fourth digit ratio (2D:4D) on latitude has been discussed in recent papers in this journal (Hurd & van Anders, 2007; Loehlin, McFadden, Medland, & Martin, 2006, 2007). Such an association was first suggested by Manning (2002), who proposed that 2D:4D was highest at intermediate latitudes and lowest at the equator and at high latitudes. In their Fig. 1, Hurd and van Anders (2007) plotted the combined data of Loehlin et al. (2006) and Manning (2002). This figure shows a clear positive latitudinal trend in 2D:4D, except that data from Finland seem an outlier from this otherwise rather linear trend. Thus, the suggestion of low 2D:4D at high latitudes depends critically on these data from Finns.

Here, we provide new, larger data on the 2D:4D of Finnish women and show that Finns have a much higher mean 2D:4D than those reported by Manning (2002) and Hurd and van Anders (2007). The mean 2D:4D of Finnish women reported by Manning (2002), based on measurements from 54 women, was approximately 0.94. Note that Hurd and van Anders (2007) seem to have used even a smaller sample (but higher mean 2D:4D of 0.95) of only 17 women from Finland, reported in Manning et al. (2000). We collected data on the right and the left hand 2D:4D from a geographically diverse sample of 287 Finnish women born 1946–1958, who participated in national screening program for cervical cancer in Turku, South-West Finland (Helle & Lilley, in press). These women are an ethnically homogeneous group, as all non-native Finns were excluded from the analysis and none of those included were born in the Sami parishes of Northern Finland. The mean 2D:4D for these women was 0.975, which is significantly higher compared to the data reported by Manning (2002) (0.94 vs. 0.975, $t(286) = 15.1, p < .0001$). When replacing data from Manning (2002) with our estimate into Hurd and van Anders's (2007) Fig. 1, Finland does not anymore seem to be an outlier (Fig. 1). Nevertheless, regressing women's 2D:4D on latitude still shows a tendency for a convex association, i.e., that 2D:4D first increases towards high latitudes but then levels off or even begins to decrease again towards very high latitudes (Fig. 1). When the data from Finns are excluded, the analysis does not anymore give statistical support for a curvilinear association between latitude and women's 2D:4D ($p = .22$ for quadratic association). Instead, this association seems linear, $\beta(95\%\ \text{CIs}) = 0.00092\,(0.00012, 0.00171), F(1, 8) = 7.06, p = .029$). This suggests that data from Finland are still responsible for the curvilinear effect of latitude on 2D:4D. More data on northern latitudes are thus needed to confirm whether 2D:4D ceases to increase or begins to decline towards the extreme high latitudes in the northern hemisphere.

In order to gain more insight to this problem, we investigated also within-population geographical variation of women's 2D:4D in Finland. While our sample was collected from women that lived in the same city at the time of the measurements, there was large geographic variation in the location of their town of birth (latitude: from 60°1′ to 66°5′ N (corresponding to ca 740 km); longitude: from 21°2′ to 29°3′ E). We took advantage of this variation and examined whether either latitude or longitude of the location of birth was related to 2D:4D, using a general linear mixed model (Littell, Milliken, Stroup, & Wolfinger, 2006; see Table 1). Laterality and its two-way interactions with latitude and longitude were included into the model to examine whether these gradients differed between the right and the left hand 2D:4D.

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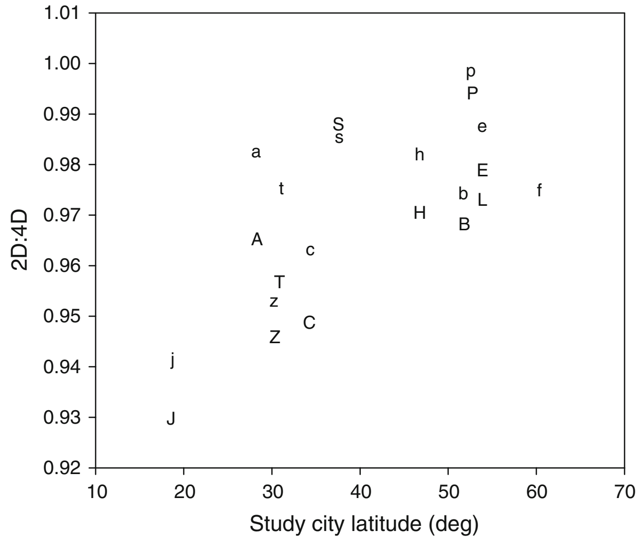

Fig. 1 Latitudinal variation of population mean 2D:4D, based on the city the research was conducted in, for males (upper case letters) and females (lower case letters), as re-drawn from Hurd and van Anders (2007). Samples are: A = Australia, B = London, C = California, L = Liverpool, P = Poland, S = Spain, T = Texas, H = Hungary, G = Germany, Z = Zulu, J = Jamaica, F = Finland (this study). A regression analysis of women's 2D:4D on latitude suggests a weak convex association (β_{linear}(95% CIs) = 0.0045 (0.00004, 0.0090), $F(1, 8) = 5.41$, $p = .048$; $\beta_{\text{quadratic}}$(95% CIs) = −0.00005 (−0.0001, 0.00001), $F(1, 8) = 3.91$, $p = .083$)

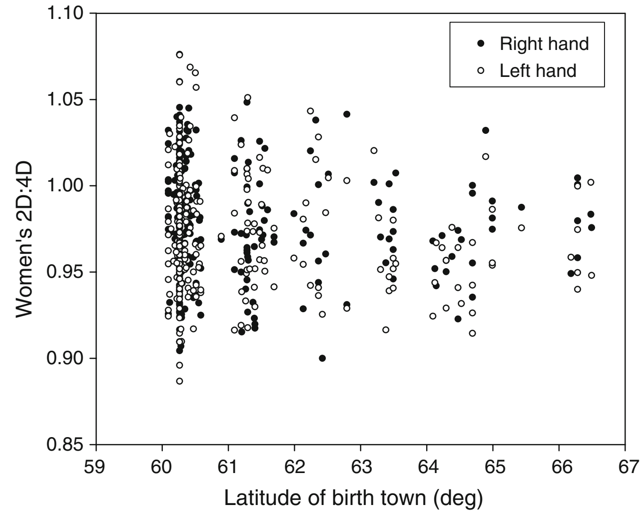

Fig. 2 The effect of latitude on 2D:4D in post-reproductive Finnish women

Interestingly, our results showed that, within the Finnish population, women's 2D:4D decreased by 0.0022 per one degree increase in latitude (Table 1, Fig. 2). This finding is in contrast with a linear positive trend in 2D:4D with latitude, but in accordance with an interpretation that 2D:4D begins to decrease towards extreme high latitudes. This result was independent of laterality (i.e., there was no interaction between laterality and latitude), but the right hand 2D:4D showed a higher mean than the left hand 2D:4D (0.978 vs. 0.972, Table 1). There was no relationship between women's 2D:4D and the longitude of place of birth (Table 1).

The 2D:4D predicted from our statistical model showed a considerable decrease from 0.979 in southern Finland (60°1′ N) to 0.962 in northern Finland (66°5′ N). A lesson to learn from this is that using the latitude of the city the research was conducted in as a measure of latitudinal variation may be a major source of error in any study interested in geographical variation of 2D:4D. This is because the current city of residence may be far away from the location where the participant's mother lived while pregnant. This will confound the signatures of any population genetic or environmental agents that may have had a causal effect on in utero steroids levels and presumably on offspring digit ratios. We therefore urge future studies on this topic to pay attention to the location of birth rather than to the location of sampling. Furthermore, in order to overrule a potential confounding effect of the possibility that women's 2D:4D was related to their tendency to move from their area of birth, we compared 2D:4D between those women who were born in Turku (where the study was conducted) and still living there with those who were living in

Table 1 The effects of laterality, latitude, and longitude on post-reproductive women's 2D:4D in Finland

Fixed factors	β(95% CIs)	*df*	*F*	*p*
Laterality	0.0061 (0.0026, 0.0095)	1, 286	12.14	.0006
Latitude	−0.0024 (−0.0046, −0.0002)	1, 285	4.62	.032
Female height	0.0004 (−0.0002, 0.0010)	1, 284	1.83	ns
Longitude	−0.0006 (−0.0030, 0.0019)	1, 283	<1	ns
Latitude × laterality	0.0014 (−0.0009, 0.0037)	1, 285	1.51	ns
Longitude × laterality	−0.0002 (−0.0028, 0.0023)	1, 284	<1	ns

Note: Model simplification of non-significant variables and interactions was done by backward elimination. Because both the woman's right and left hand 2D:4D were used as a response variable, female identity was fitted as a random factor (estimate ± SE of the variance component = 0.00058 ± 0.00007). It explained 57.4% of variation in 2D:4D. The denominator degrees of freedom of fixed factors were estimated with Satterthwaite's formula (Littell et al., 2006). The model residuals were normally distributed (Kolmogorov-Smirnov's test, $p > .15$). CI = confidence interval

Turku but born elsewhere in Southern Finland (ranging $\pm 1°$ N from the latitude of Turku). The analysis showed no difference in 2D:4D between these two groups of women (0.977 vs. 0.978), $F(1, 203) < 1$, while controlling for laterality.

Hurd and van Anders (2007) also suggested that the association between 2D:4D and latitude might be explained by latitudinal variation in height. This explanation was rejected by Loehlin et al. (2007) on the basis of such an association not being found within populations. Indeed, most of the studies on the subject have found no evidence for such an association (Fink, Neave, & Manning, 2003; Manning, Scutt, Wilson, & Lewis-Jones, 1998; Neave, Laing, Fink, & Manning, 2003; Rahman, Korhonen, & Aslam, 2005). Our data did not support such an association either, as we found no correlation between height and women's 2D:4D (Table 1). However, since some other studies have found lower 2D:4D among taller individuals (Barut, Tan, & Dogan, 2008; Tester & Campbell, 2007), the issue may warrant further examination.

In conclusion, there seems to be a latitudinal variation in 2D:4D. The combined examination of the between- and within-population data seems to support the idea that the association is convex rather than linear, but more data from the northern latitudes are needed to confirm the shape of this association. While the existence of such a clear geographic gradient in 2D:4D is exciting, it is also puzzling, as there does not seem to be any known a priori reason why latitude should be associated with 2D:4D. Naturally, one would invoke temperature, sunlight, and/or day-length patterns as potential factors mediating such latitudinal effects. However, if the association between 2D:4D and latitude eventually proves to be curvilinear, day length or temperature related patterns may be unlikely to provide the answer. The association might thus more likely result from genetic differences among populations. Examining whether the underlying mechanisms for latitudinal differences in 2D:4D are associated with latitudinal adaptation will nevertheless be an exciting direction for further research.

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