Human Biology Review (ISSN 22774424) ***www.HumanBiologyJournal.com***
International Peer Reviewed Journal of Biological Anthropology
Volume 14, Number 2, April-June 2025 Issue

Original scientific paper

Digit ratio and its relationship with height, weight and BMI among the Santal community of Purba Bardhaman, West Bengal, India

A. Ray[1], S. Sobnam[2], A. Mukhopadhyay[3], S. Biswas[4], M. Bhadra[5*]

Human Biology Review, Volume 14 (2), pp. 126-134

Revised and accepted on March 20, 2025

Citation: Ray A, Sobnam S, Mukhopadhyay A, Biswas S and Bhadra M. 2025. Digit ratio and its relationship with height, weight and BMI among the Santal community of Purba Bardhaman, West Bengal, India. Human Biology Review, 14 (2), 126-134.

Authors and affiliations

Avik Ray[1], Sohela Sobnam[2], Ashish Mukhopadhyay[3], Subir Biswas[4], Mithu Bhadra[5*]

[1] UGC-SRF, Department of Anthropology, West Bengal State University, Barasat, West Bengal – 700126, Email: avikray2703@gmail.com

[2] Ex-Post Graduate Student, Department of Anthropology, West Bengal State University, Barasat, West Bengal – 700126, Email: sohelasobnam0@gmail.com

[3] Associate Professor, Department of Anthropology, Acharya Prafulla Chandra College, New Barrackpore, West Bengal – 700131, Email: apcc1960@gmail.com

[4] Professor, Department of Anthropology, West Bengal State University, Barasat, West Bengal – 700126, Email: subir@wbsu.in

[5] Assistant Professor, Department of Anthropology, Dinabandhu Mahavidyalaya, Bongaon, West Bengal – 743235, Email: drmithubhadra@gmail.com

[*] Corresponding Author: Mithu Bhadra, Assistant Professor, Department of Anthropology, Dinabandhu Mahavidyalaya, Bongaon, West Bengal – 743235, Email: drmithubhadra@gmail.com

Digit ratio and its relationship with height, weight and BMI among the Santal community of Purba Bardhaman, West Bengal, India

A. Ray[1], S. Sobnam[2], A. Mukhopadhyay[3], S. Biswas[4], M. Bhadra[5*]

Citation: Ray A, Sobnam S, Mukhopadhyay A, Biswas S and Bhadra M. 2025. Digit ratio and its relationship with height, weight and BMI among the Santal community of Purba Bardhaman, West Bengal, India. Human Biology Review, 14 (2), 126-134.

Avik Ray[1], Sohela Sobnam[2], Ashish Mukhopadhyay[3], Subir Biswas[4], Mithu Bhadra[5*]

ABSTRACT:

Over the past twenty years, numerous studies have investigated the connection between the biomarker known as the digit ratio (2D:4D) and various indicators of pre- and post-natal stress during development. This research is based on the premise that the digit ratio may act as a potential indicator of prenatal exposure to androgens and oestrogens. In the present study, height, weight and BMI have been selected to serve as indicators of developmental stress and whether there is any association or correlation with digit ratio (2D:4D) or whether digit ratio is a sufficient predictor of said stress indicators. 359 Santal males were sampled randomly from various blocks of the Purba Bardhaman district of West Bengal, India to have their height, weight and digit lengths measured. Digit ratios of both hands were then correlated with height and linear regression models were constructed to predict relevant significant variable(s) with digit ratios as the predictors. After categorizing the digit ratios as ordinal categories with quartile classification, Kruskal-Wallis test was then performed to test any significant differences between the said categories in terms of dependent variables. Only height correlated significantly negatively with digit ratios of both hands at $p < 0.01$ level. Upon regressing the digit ratios with height as the dependent variable, R^2 values of 0.032 and 0.011 were found for the left and right hands respectively. Significantly higher height was observed in the low category of digit ratio in comparison to the very high category. It can be concluded from the study that digit ratio can be used as a predictor of height but yields a poor linear model fit.

Keywords: *digit ratio, developmental stress, human development, Santals, biological anthropology*

INTRODUCTION:

The identification of digit ratio as a potential biomarker of developmental stress has been an ongoing scientific process of confirmation and rejection, with a few general trends that were found to be consistent across studies. It has been posited that lower fetal exposure to testosterone and higher exposure to estrogen increases the digit length of the 2nd digit relative to the 4th digit of each hand and since exposure to sex steroids is essential for fetal development in terms of robusticity of muscles, bones and the immune system, a deviation from the norm may be understood as a marker of developmental instability (Manning, et al., 1998). This ratio of the 2nd and 4th digit length has been found to be highly sexually dimorphic with lower 2D:4D in males than females (Trivers, et al., 2006; Manning, et al., 1998). Evidence of digit ratio remaining more or less stable since birth is ample on both ends of the debate with some studies reporting that no significant changes in digit ratio were observed with an increase or decrease in age (Králík, et al., 2014; Butovskaya, et al., 2021), while others reported positive correlation and association (Williams, et al., 2003; Gillam, et al., 2008) and yet a few has reported negative association (Fink, et al., 2004).

It has been also suggested that men with lower, more androgenized finger length ratios had higher physical aggression scores in the Buss and Perry Aggression Scale (Bailey & Hurd, 2005), higher prevalence of dark triad personality (Borráz-León, et al., 2019) and other criteria associated with the effects of higher androgen on the brain. On the other hand, digit ratio is also shown to correlate positively with higher BMI independent of age or income but correlates negatively with parental income inequality. The explanation to this phenomenon and other morbidities arising from pre-natal developmental stress is explained by the Trivers-Willard effect which states that high-income women may prenatally masculinize their sons at the expense of the fitness of their daughters. Women with low income may prenatally feminize their daughters at the fitness expense of their sons, and thus parental income inequality may influence both prenatal sex steroids and BMI such that increases in inequality result in reductions in prenatal testosterone and increases in BMI at the individual and national level (Manning, et al., 2022). Also, both men and women with higher fat deposition in arms, thighs and lower legs were reported to have a relatively higher digit ratio suggesting an association between higher prenatal oestrogen exposure and body weight (Iljin, et al., 2022). Negative correlations between height and digit ratio have also been reported, with male left digit ratio and female right digit ratio correlating significantly (Barut, et al., 2008). Association of lower digit ratio in females with late age of menarche, higher mean age of pregnancy in mothers, dysmenorrhea, heavier bleeding during menses and infertility has also been reported (Tabachnik, et al., 2020)

OBJECTIVES:

This pattern of contradictory pieces of evidence from various studies saturates the science of digit and the reliability of the same as a tentative biomarker for developmental perturbations has not been clearly established. This study attempts to bridge that gap and examine whether the said marker actually do have any predictive properties of morbidity. The objectives of the study can be presented as such:

1. To determine whether digit ratio is significantly correlated with height, weight and BMI.
2. To determine whether digit ratio is a reliable predictor of height, weight and BMI.

METHODS:

Study Design: The present study is correlational and cross-sectional in nature. All data used in the study was acquired through fieldwork and in-situ anthropometry in daylight within a span of a week.

Study Area and Population: 359 males of the Santal tribe were sampled for the study from the various blocks within the district of Purba Bardhaman, West Bengal. Individuals with physical disabilities pertaining to digits and long bones were excluded to minimize outliers. Individuals who were 21 years of age or older were sampled since any possibility of bone growth had to be eliminated and since any change in height is unexpected after that age (Taranger & Hägg, 1980) (Hasan, et al., 2020), the possibility of any spurious correlation between height and measured variables due to allometric changes in bone dimensions is reduced. The upper limit of age set for the criterion to be included in the study was set to 49 years so that no decrement in height can be expected after this age (Hasan, et al., 2020) cannot similarly affect the correlations.

Sampling: First blocks in the district of Purba Bardhaman district of West Bengal with an adequate Santal population were selected and then a simple random sampling of individuals from the Panchayat Electoral Voter list who fall within the required age range of 21-49 years were performed.

Measurements: The height and weight of all individuals were measured using a stadiometer in centimeters (cm) and a digital weighing scale in kilograms (kg) respectively. For the measurement of digit lengths of the 2nd and 4th digit of both hands, a digital Vernier Caliper was employed to measure the distance from the palmar proximal crease to the distal tip of the fingers in millimeters (mm) (Mayhew, et al., 2007). All the anthropometric measurements were performed twice and were found to be at around 0.75% intra-observer %TEM, which is considered to be acceptable (Goto & Mascie-Taylor, 2007).

Data Analysis: All collected data were entered into an IBM-SPSS 26.0 datasheet and the same software package was used to analyse all data. BMI was derived from the formula:

$$BMI = \frac{Weight\ (in\ Kg)}{Height^2\ (in\ m^2)}$$

Digit Ratio (DR) for both hands was calculated by dividing the length of the 2nd digit by the 4th digit and was designated as LDR for the left hand and RDR for the right hand.

Statistical Analysis: All the measured variables were first tested for normality and statistical tests to compare their means were adjusted accordingly. For DR, classification was performed by dividing them into quartiles: “Low”, “Moderate”, “High” and “Very High”. The digit ratio was then put through Spearman’s rho rank correlation to detect any positive or negative correlation with height, BMI and weight. All significant correlations were then fitted into a regression model with the digit ratios as predictors. Kruskal-Wallis test was performed to calculate any significant differences between the heights of the digit ratio categories. All statistical tests and analyses are flagged as significant at $p < 0.05$ level.

RESULTS:

Table 1 displays that the average height with Standard Deviation (SD) in the sample is approximately 163.73 ± 5.67 cm, ranging from 142 to 184.1 cm. For all digit lengths, the mean digit lengths seem to be greater in the left hand than in the right hand. The mean LDR ± SD and RDR ± SD is 0.97 ± 0.06. The mean BMI ± SD is 20.56 ± 3.01 Kg/m^2. Excess kurtosis value greater than +2 is observed in LDR and RDR suggesting leptokurtosis (George & Mallery, 2010).

Table 2 displays the Spearman correlation matrix between digit ratio, height, BMI and weight. The left and right DR have a Spearman’s ρ value of - 0.145 and 0.143 at $p < 0.01$ with height suggesting a very weak but significant negative correlation. No correlation between BMI, weight and digit ratio was observed.

Table 3 shows the regression equations derived from observed correlations between height, LDR and RDR. Considering height as the dependent variable and LDR and RDR as predictors, a linear regression model was constructed R^2 values of 0.032 and 0.011 with p-values <0.001 and 0.048 respectively. It seems to be the case that LDR is better fitted into a predictive model of height than RDR.

Table 4 shows a quartile-wise categorisation of left and right digit ratio with four designated categories based on the same: Low, Moderate, High and Very High.

Table 5 shows Kruskal-Wallis test of differences in height between various categories of digit ratio. There seems to be no significant differences between categories of LDR in terms of height but in the case of RDR, there seems to be an overall difference between the categories at $p < 0.05$ level, and specifically among the categories of Very High and Low at $p < 0.01$. The mean rank of Very High is 157.18 which is lower than the mean rank of 202.42 of the Low category suggesting significantly taller heights among those with low RDR in comparison to those that have very high RDR.

Table 1: Descriptive Statistics of all measured and derived variables

Variables	Mean ± SD (n = 359)	Min	Max	Skewness	Excess Kurtosis
LD2†	68.32 ± 04.19	54.46	81.51	- 0.09	00.42
LD4†	70.25 ± 04.56	58.00	85.10	0.04	- 00.24
RD2†	67.85 ± 04.21	52.14	81.64	- 0.06	00.25
RD4†	70.01 ± 04.78	56.00	84.64	- 0.06	- 00.20
LDR	00.97 ± 00.06	00.69	01.13	- 0.45	02.54
RDR	00.97 ± 00.06	00.72	01.36	0.96	07.41
Height (Cm)	163.73 ± 05.67	142.00	184.10	0.02	00.72
Weight (Kg)	57.55 ± 09.24	36.00	89.00	0.56	00.67
BMI (Kgm^{-2})	20.56 ± 03.01	12.73	30.54	0.48	00.35

† in millimetres (mm)

Table 2: Spearman correlation matrix between height, DR, BMI and Weight

Variables	L-2D:4D	R-2D:4D	Height	BMI	Weight
LDR	-				
RDR	0.596**	-			
Height	- 0.145**	- 0.143**	-		
BMI	0.050	- 0.013	- 0.003	-	
Weight	- 0.024	- 0.061	0.427	0.875**	-

*** significant at p < 0.01*

Table 3: Linear regression models predicting height from digit ratios

Models	R	Adjusted R^2	Sum of Squares	F-value	p-value
Height = 181.415 – 18.154 (LDR)	0.179	0.032	367.028	11.767	<0.001**
Height = 173.244 – 9.798 (RDR)	0.105	0.011	125.867	3.950	0.048*

** significant at p < 0.05, ** significant at p < 0.01*

Table 4: Quartile Classification of digit ratio

Variables	< 25th percentile	25-50th percentile	50-75th percentile	> 75th percentile
LDR	< 0.9459	0.9459 – 0.9721	0.9722 – 1.0019	> 1.0019
RDR	< 0.9403	0.9403 – 0.9697	0.9698 – 1.0000	> 1.0000
Category	Low	Moderate	High	Very High

Table 5: Kruskal-Wallis Test of differences in height between categories of digit ratio

Parameters	Categories	Mean Ranks of Height	Standardized Kruskal-Wallis H	df	p-value
LDR	-	-	7.503	3	0.057
RDR	-	-	7.905	3	0.048*
	Very High - Moderate	157.18 – 173.16	0.960	1	0.337
	Very High - High	157.18 – 181.42	1.514	1	0.130
	Very High - Low	157.18 – 202.42	2.713	1	0.007**
	Moderate - High	173.16 – 181.42	- 0.562	1	0.574
	Moderate - Low	173.16 – 202.42	1.897	1	0.058
	High - Low	181.42 – 202.42	1.424	1	0.693

** significant at p < 0.05, ** significant at p < 0.01*

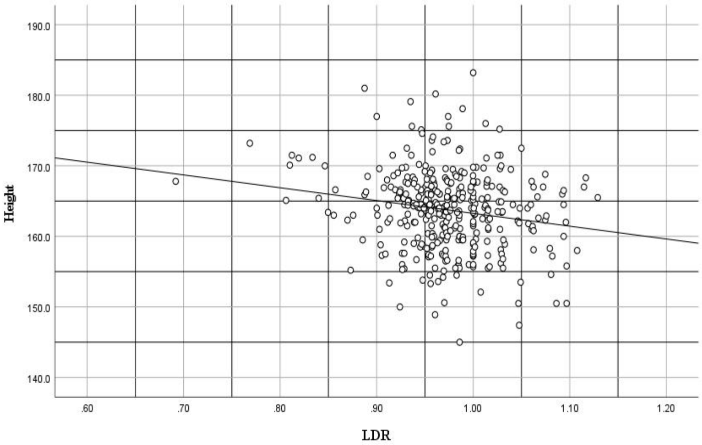

Figure 1: Scatter plot diagram of height and LDR

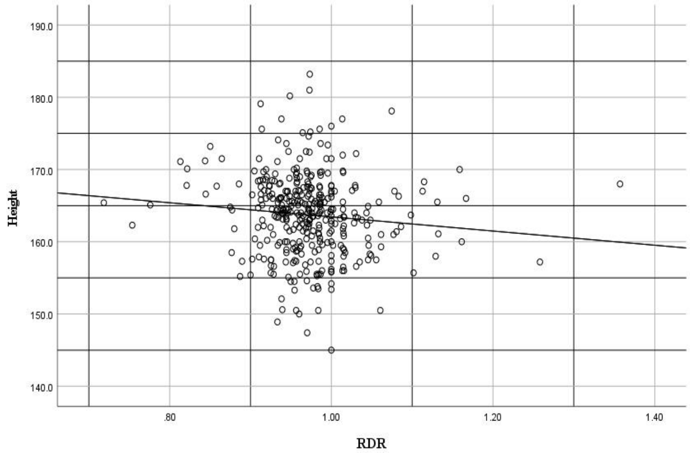

Figure 2: Scatter plot diagram of height and RDR

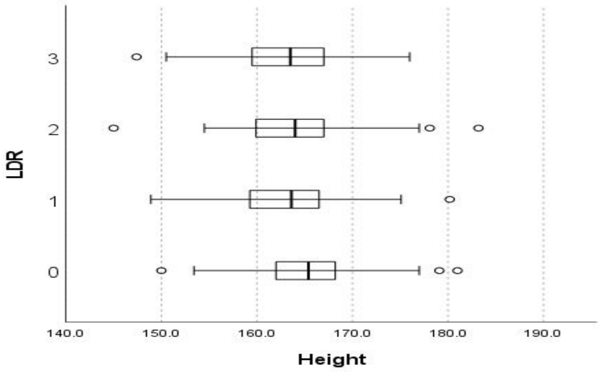

Figure 3: Box plot of height and LDR

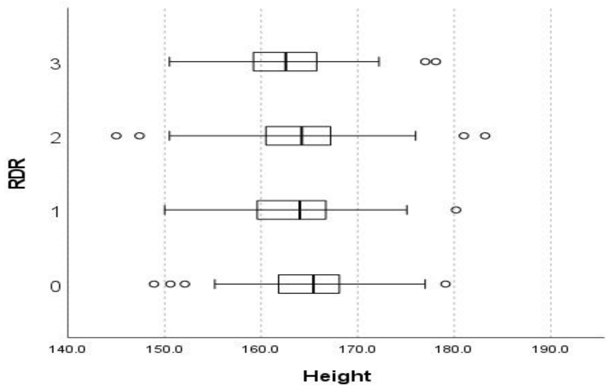

Figure 4: Box plot of height and RDR

DISCUSSION:

From the results, it is clear that digit ratios of both hands correlates negatively albeit very weakly with height. This finding is in accordance with an earlier study which found negative association between height and digit ratio (Barut, et al., 2008). This study also did not find any correlation between digit ratio and BMI or weight which has also been demonstrated in males but not in females in an earlier study (Manning, et al., 2022). It could be that the reason why digit ratios correlate only with height (Jacob, et al., 2015) is because prenatal steroid exposure has some association with growth during puberty (Doyle, et al., 2000), owing to the former being a biomarker of developmental perturbation, whereas weight and BMI are heavily influenced by lifestyle choices and diet (Patel & Hu, 2012) (Smith, 2007). As a predictor of height, digit ratios perform quite poorly with the left digit ratio explaining around 3.2% of all the variances in height and the right explaining around 1.1%. Both from Spearman's rho and from linear regression modelling it is clear that the left digit ratio has a higher association with height than the right digit ratio. This is in contrast to the idea that the right digit ratio is more sensitive to prenatal steroids than the left (Manning, et al., 1998). The Kruskal-Wallis test found significant differences in height between individuals with very high digit ratio and low digit ratio in the right hand. Interestingly, no significant differences in the categories of digit ratio for the left hand were observed.

Conclusion:

This study shows that digit ratio has a negative correlation with height, but does not correlate with weight or BMI. The relationship between height and digit ratios seems to be linear with the left digit ratio being a better albeit overall poor predictor of height than the right digit ratio. Individuals with lower right digit ratios also seem to be significantly taller than those who have very high digit ratios. Overall, more studies exploring the relationship between height and digit ratio need to be performed to completely understand the relationships between the said variables but this study does contribute to the growing body of evidence that the nature of the association between them is negative correlation.

Conflict of interest:

No potential or present conflict of interest has occurred.

Funding:

The present study was completely self-funded.

REFERENCES:

Bailey, A., & Hurd, P. (2005). Finger length ratio (2D:4D) correlates with physical aggression in men but not in women. *Biol Psychol 68(3)*, 215-222.

Barut, C., Tan, U., & Dogan, A. (2008). Association of height and weight with second to fourth digit ratio (2D : 4D) and sex differences. *Percept Mot Skills, 106*(2), 627-632.

Borráz-León, J., Rantala, M., & Cerda-Molina, A. (2019). Digit ratio (2D:4D) and facial fluctuating asymmetry as predictors of the dark triad of personality. *Pers Individ Diff 137*, 50-55.

Butovskaya, M., Burkova, V., Apalkova, Y., Dronova, D., Rostovsteva, V., Karelin, D., et al., (2021). Sex, population origin, age and average digit length as predictors of digit ratio in three large world populations. *Sci Rep, 11*, 8157.

Doyle, L., Ford, G., Rickards, A., Kelly, E., Davis, N., Callanan, C., & Olinsky, A. (2000, July). Antenatal corticosteroids and outcome at 14 years of age in children with birth weight less than 1501 grams. *Pediatrics, 106*(1). doi:10.1542/peds.106.1.e2.

Fink, B., Manning, J., Neave, N., & Tan, U. (2004). Second to fourth digit ratio and hand skill in Austrian children. *Biol Psychol*(46), 558-664.

George, D., & Mallery, P. (2010). *SPSS for Windows Step by Step: A Simple Guide and Reference 17.0 Update 10th Edition.* Boston: Pearson.

Gillam, L., McDonald, R., Ebling, F., & Mayhew, T. (2008). Human 2D (index) and 4D (ring) finger lengths and ratios: cross-sectional data on linear growth patterns, sexual dimorphism and lateral asymmetry from 4 to 60 years of age. *J Anat, 213*(3), 325-335.

Goto, R., & Mascie-Taylor, C. (2007, March). Precision of measurement as a component of human variation. *J Physiol Anthropol, 26*(2), 253-256. doi:10.2114/jpa2.26.253

Hasan, M., Yokota, F., Islam, R., Hisazumi, K., Fukuda, A., & Ahmed, A. (2020, March 10). A Predictive Model for Height Tracking in an Adult Male Population in Bangladesh to Reduce Input Errors. *Int J Environ Res Public Health, 17*(5), 1806.

Iljin, A., Antoszewski, B., Szewczyk, T., & Sitek, A. (2022). The 2D:4D index is associated with the development of excess body weight in adults, but not with the rate of weight loss following bariatric surgery. *Sci Rep, 12*, 8078.

Jacob, M., Avadhani, R., Nair, B., Nallathamby, R., & Soman, M. (2015). Cross sectional study of second and fourth digit ratio with physical attributes in South Indian population. *Int J Anat Res, 3*(2), 1133-1137.

Králík, M., Gronkiewicz, S., Ingrová, P., & Kozieł, S. (2014). Changes in digit ratio during puberty: X-ray sample from the Wrocław longitudinal study of twins. *Academy of Sciences of the Czech Republic, Masaryk University*.

Manning, J., Fink, B., Mason, L., & Trivers, R. (2022). Digit ratio (2D:4D) and body mass index in the BBC Internet Study: prenatal sex steroids and a Trivers-Willard effect on body composition. *J Biosoc Sci*, 902-911.

Manning, J., Scutt, D., Wilson, J., & Lewis-Jones, D. (1998). The ratio of 2nd to 4th digit length: A predictor of sperm numbers and levels of testosterone, LH and oestrogen. *Hum Reprod*(13), 3000-3004.

Mayhew, T., Gillam, L., McDonald, R., & Ebling, F. (2007). Human 2D (index) and 4D (ring) digit lengths: their variation and relationships during the menstrual cycle. *J Anat, 211*(5), 630-638.

Patel, S., & Hu, F. (2012). Short sleep duration and weight gain: A systematic review. *Obesity, 16*(3), 643-653.

Smith, M. (2007). Obesity and sex steroids during gonadotropin-releasing hormone against treatment for prostate cancer. *Clin Cancer Res, 13*(1), 241-245.

Tabachnik, M., Sheiner, E., & Wainstock, T. (2020, April 14). The association between second to fourth digit ratio, reproductive and general health among women: findings from an Israeli pregnancy cohort. *Sci Rep, 10*(1), 6341. doi:10.1038/s41598-020-62599-3

Taranger, J., & Hägg, U. (1980). The timing and duration of adolescent growth. *Acta Odontol Scand, 38*(1), 57-67.

Trivers, R., Manning, J., & Jacobson, A. (2006). A longitudinal study of digit ratio (2D:4D) and other finger ratios inJamaican children. *Horm Behav*(49), 150-156.

Williams, J., Greenhalgh, K., & Manning, J. (2003). Second to fourth finger ratio and possible precursors of developmental psychopathy in preschool children. *Early Hum Dev*(72), 57-65.