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Human Biology Review (ISSN 2277 4424) 4 (4) 2015
Original Scientific Paper (Datta Banik et al. pp.378-386)
Revised and Accepted on October 7, 2015

# Fluctuating asymmetry of hand and foot dimensions among University girl students from Bilaspur, India

S. Datta Banik[1], M. Ghritlahre[2], S. Das[3] and K. Bose[4]

*Citation: Datta Banik S, Ghritlahre M, Das S and Bose K. 2015. Fluctuating asymmetry of hand and foot dimensions among University girl students from Bilaspur, India. Human Biology Review, 4 (4), 378-386.*

[1] Sudip Datta Banik, Department of Human Ecology. Cinvestav-IPN, Merida, Yucatan, Mexico. Email: sdbanik@hotmail.com.
[2] Manisha Gritlahre, Department of Anthropology and Tribal Development, Guru Ghasidas Vishwavidyalaya, (A Central University), Bilaspur, Chhattisgarh, India. Email: manisha.ggu@gmail.com.
[3]Subal Das[2] Department of Anthropology and Tribal Development, Guru Ghasidas Vishwavidyalaya, (A Central University), Bilaspur, Chhattisgarh, India. Email: dsubalvu@gmail.com.
[4]Kaushik Bose, Department of Anthropology, Vidyasagar University, Midnapore, West Bengal, India. Email: kaushikbose@cantab.net

Corresponding Author: Sudip Datta Banik, Department of Human Ecology. Centro de Investigación y de Estudios Avanzados (Cinvestav) del IPN. Merida, Yucatan, Mexico. Email: sdbanik@hotmail.com; dattabanik@mda.cinvestav.mx.

## *ABSTRACT*

***Background:*** *Asymmetry of bilateral measurements in human body is a common phenomenon and low asymmetry predicts canalization and developmental stability of morphological characteristics.*
***Methods:*** *A study was done in 2012 on fluctuating asymmetry (FA) of hands and feet (length and breadth) among 135 girl students, aged 18–22 years in a University in Bilaspur, Chhattisgarh, India.*
***Results:*** *Mean individual absolute FA was 0.01 for each bilateral trait. Paired difference between two sides of hand and foot dimensions was not significant except for hand breadth ($t= 2.03$, $p< 0.05$). Correlation between bilateral measurements of hands and feet (length and breadth) was significant ($p< 0.05$) and asymmetry was marginal. In conclusion, low bilateral asymmetry and high correlation between sides indicate canalization, similarities in environmental as well as developmental-genetic programs for these dimensions of hands and feet.*

***Key words:*** *Bilateral asymmetry, hand length, hand breadth, foot length, foot breadth.*

## INTRODUCTION

Natural selection shapes phenotypic evolution where genotype is under constant interaction with environmental change. The developmental process of phenotype is controlled by plasticity, canalization and stability (Waddington, 1942, 1953). Developmental instability in morphological characteristics assumes environmentally or genetically induced deviations from ideal phenotypes with relatively poor genetic qualities. Population variation in phenotypes is therefore linked with mutation, migration, genetic admixture and environmental factors that indicate phenotypic plasticity has important adaptive effects. On the other hand, the ability of producing consistent phenotype in spite of these factors is referred to as canalization. This kind of physiological homoeostasis buffers and maintains developmental stability, a tendency to follow particular trajectories, despite genetic or environmental deviations (Debat & David, 2001; Wagner et al., 1997). The canalization model therefore, predicts a stabilization of selection in favor of genetic variants to reduce environmental variability and effects of mutation (Gibson & Wagner, 2000). Therefore, traits having high genetic variance will get better chance to stabilize selection, producing canalization (Wagner et al., 1997).

Bilateral symmetry is ubiquitous in the life-forms (Weyl, 1952). Asymmetry study of morphological traits might be important in estimation of developmental stability and canalization. The studies on developmental stability and canalization of traits in humans are relatively few in number (Jantz & Webb, 1980; Kieser et al., 1986; Livshits & Smouse, 1993; Reddy, 1999). Phenotypic variability in humans in the process of evolution might also have weak correlation with asymmetry, indicating the later to be a poor estimator of canalization (Palmer & Strobeck, 2003). Inheritance of morphological traits in humans is generally considered to be quantitative where exact genetic mechanisms (polygenic and polymorphic) are quite difficult to establish. In addition, natural selection for genetic redundancy and epistatic effects of genetic interactions between loci are not mutually exclusive by which canalization can evolve (Hallgrimsson et al., 2002). Fluctuating asymmetry (FA) is defined as random and minor deviations from perfect symmetry in paired or bilateral traits where mean population difference

between right and left sides is zero (Palmer & Strobeck, 1986, 1992, 1997; Van Valen, 1962). The FA is a measure of developmental noise and also of developmental instability of the phenotypes, affected by genetic and environmental stress leading to the developmental plasticity for adaptation. Therefore, FA might be considered to be a deviation from developmental stability and canalization.

There are many studies reported on bilateral asymmetry of anthropometric traits in humans. The FA for ear (length and breadth), length of fingers, width of elbow, wrist, ankle, and foot among adult Hazda of Tanzania was significantly ($p< 0.05$) higher than adult US college students of New Mexico (Gray & Marlowe, 2002). Asymmetry measurements of length (ear) and breadth (ear, biepicondylar, bicondylar, bistyloid, bimalleolar, hand, and foot) were recorded among infants, children and adults in Tel Aviv, Israel. The FA had shown positive and significant ($p< 0.05$) correlation between parents and children (Livshits & Kobyliansky, 1989). Another asymmetry study of the same morphometric traits among Israeli adults revealed FA of characteristics was uncorrelated with each other (Livshits & Smouse, 1993).

In the background of the studies on asymmetry as an estimator of canalization and developmental stability, our interest was to study the FA in bilateral measurements of hands and feet (length and breadth) among adult female university students from Bilaspur, Chhattisgarh, India. Bilateral differences of hand and foot dimensions were studied in adult Nigerian women (Bob-Manuel & Didia, 2008) and also among young University women from Nigeria (Ibeachu et al., 2011) and India (Khanapurkar & Radke, 2012). Studies on bilateral asymmetry of foot dimensions were reported from adults in Turkey (Zeybek et al., 2008) and India (Krishan et al., 2011; Krishan & Sharma, 2007).

Bilateral asymmetry of hands and feet are relatively less reported from India. Considering this point, there was need for further research to elucidate the bilateral asymmetry of hands and feet. The hypothesis of the present study was that minimum asymmetry in bilateral morphological traits in humans predicts canalization and developmental stability. Therefore, objectives of the present study among adult females were to compute bilateral differences and fluctuating asymmetry of hands and feet dimensions (length and breadth) and shed light on canalization and developmental stability of these traits.

## MATERIALS AND METHODS

The present cross-sectional study was done in 2012 among 135 young-adult girl students aged 18–22 years at Guru Ghasidas Vishwavidyalaya, a University in Bilaspur, Chhattisgarh, India. Ethical approval was obtained from the appropriate authority and consent was obtained from the participants before taking the measurements. Length (cm) and breadth (cm) of hands and feet were measured following standard methods (Lee & Nieman, 2007). Measurements were taken by either of the two of co-authors (MG and SD). Technical errors of measurements (TEMs) were found to be within reference values (Ulijaszek & Kerr, 1988). Test-retest reliability was estimated using intra-class correlation coefficients (ICC, repeated measures) with 95% confidence intervals (mean difference ± 1.96 SD) (Bland & Altman, 1986); the anthropometric measurement ICC values were above 0.85 (Altman, 1999). Hand and foot dimensions (length and breadth) were normally distributed following assumptions (Shapiro-Wilk test, $p > 0.05$). The normality test results included: hand length (right, statistic = 0.991; left, statistic = 0.988), hand breadth (right, statistic = 0.989; left, statistic = 0.992), foot length (right, statistic = 0.982; left, statistic = 0.989) and foot breadth (right, statistic = 0.986; left, statistic = 0.988).

Hand index and foot index [(breadth / length) x 100] were calculated for left and right sides separately (Ibeachu et al., 2011; Moudgil et al., 2008). Average length, breadth, and indices of hands and feet were computed. The individual absolute FA of bilateral measurements hands and feet (length and breadth) was calculated using standard formula (Karmakar et al., 2013).

$$FA_{ij} = (X_iR - X_iL) - 1 / n \ \Sigma(X_iR - X_iL)$$

Where, $X_i$ = trait (X) of individual (i); R, L = right and left, n = size of the sample and $FA_{ij}$ is the value of FA of trait (j) in the i-$^{th}$ individual. All statistical analyses were done using the SPSS (Version 13.00, Chicago IL, USA) program**.** All analyses were run using a 5% significance level ($\alpha$= 0.05).

## RESULTS

**Table 1: Descriptive statistics and asymmetry of hand dimensions**

| Variables | Mean (SD) |
|---|---|
| Age (years) | 20.15 (1.24) |
| Hand length-right (cm) | 16.83 (0.73) |
| Hand length-left (cm) | 16.85 (0.74) |
| Hand length-average (cm) | 16.84 (0.73) |
| Hand breadth-right (cm) | 8.64 (0.42) |
| Hand breadth-left (cm) | 8.61 (0.42) |
| Hand breadth-average (cm) | 8.62 (0.41) |
| Hand index-right | 51.37 (2.37) |
| Hand index-left | 51.13 (2.26) |
| Hand index-average | 51.25 (2.22) |
| FA-hand length (absolute) | 0.01 (0.01) |
| FA-hand breadth (absolute) | 0.01 (0.01) |

SD: Standard deviation; FA: Fluctuating asymmetry.

**Table 2: Descriptive statistics and asymmetry of foot dimensions**

| Variables | Mean (SD) |
|---|---|
| Foot length-right (cm) | 23.45 (1.03) |
| Foot length-left (cm) | 23.44 (0.96) |
| Foot length-average (cm) | 23.44 (0.97) |
| Foot breadth-right (cm) | 8.55 (0.53) |
| Foot breadth-left (cm) | 8.54 (0.61) |
| Foot breadth-average (cm) | 8.55 (0.54) |
| Foot index-right | 36.49 (2.07) |
| Foot index-left | 36.45 (2.41) |
| Foot index-average | 36.47 (2.10) |
| FA-foot length (absolute) | 0.01 (0.01) |
| FA-foot breadth (absolute) | 0.01 (0.04) |

SD: Standard deviation; FA: Fluctuating asymmetry.

Mean age of the girl participants was 20.15 ± 1.24 years SD (Standard deviation). Average estimates of hand dimensions were: breadth (8.62 ± 0.41 cm), length (16.84 ± 0.73 cm) and index (51.25 ± 2.22). Separate measurements of two sides indicated marginal differences in mean values (hand breadth 0.03 cm higher in right side; hand

length 0.02 cm higher in left side). Mean individual absolute FA was 0.01 for hand breadth and length (Table 1). Likewise, average foot dimensions were: breadth (8.55 ± 0.54 cm), length (23.44 ± 0.97 cm) and index (36.47 ±2.10). Mean individual absolute FA was also 0.01 for foot breadth and length (Table 2). Paired difference between two sides was significant only for hand breadth ($t$= 2.03, $p$< 0.05). Correlation of measurements between two sides was significant for hand and foot dimensions (r > 0.8, $p$< 0.05).

## DISCUSSION

In the present study, the bilateral difference and FA was very small with respect to hand and foot measurements (length and breadth) in young adult women University students. In a study among 18-30 year-old University women-students in Nigeria (Ibeachu et al., 2011), left hand length was marginally higher than the right hand length (Right 17.62 ± 0.07 cm, left 17.69 ± 0.07 cm) while in the breadth there was a reverse finding (Right 7.69 ± 0.03 cm, left 7.58 ± 0.03 cm). The present study conforms to this earlier one for bilateral differences in hand length and hand breadth. In the present study, hand index (Average: 51.25 ± 2.22) of Indian women suggested to be hyperbrachycheir according to Krogman hand index (Ibeachu et al., 2011). On the other hand, average hand index of the Nigerian women was 43.29±0.14 and the population studied belonged to two groups of hand dimension: dolichocheir (41.0-43.9) and mesocheir (44.0-46.9) (Ibeachu et al., 2011).

A study among adult Nigerian women on foot dimensions reported higher mean values for right side of either length or breadth (Foot length: right 25.00 ± 1.33 cm, left 24.75 ± 0.17 cm; foot breadth right 9.14 ± 0.58 cm, left 8.92 ± 0.08 cm) (Bob-Manuel & Didia, 2008). The results from the present study on young adult women reports marginal bilateral differences in foot dimensions along with smaller foot size (either length or breadth) compared to the Nigerian sample.

In a sample of 13-18 year-old young women from northern India, significant difference between sides was observed for foot length. However, foot length measurements did not show any statistically significant bilateral asymmetry (Krishan et al., 2011). Bilateral variation was not significant for the measurements except hand

breadth (Krishan & Sharma, 2007). In the present study, correlation between bilateral measurements of hands and feet (length and breadth) was significant ($p< 0.05$) and asymmetry was marginal.

In the light of canalization, we may conclude that high correlation and very low asymmetry between bilateral measurements on hands and feet from the sample of young adult women reflect developmental stability in these traits and marginal developmental noise. Further, the results might indicate similarities in environmental as well as developmental-genetic programs for these bilateral dimensions of hands and feet. The minor bilateral differences observed are due to stochastic variation in development process.

**ACKNOWLEDGEMENTS**

The authors thank the scholars and faculty members of the Department of Anthropology & Tribal Development, Guru Ghasidas Vishwaviyalaya for their support. We are grateful to the participants. The authors are also thankful to Ms. Varsha Sandilya for her kind help during data collection.

**REFERENCES**

Altman DG. 1999. *Practical statistics for medical research*. Chapman & Hall, London.

Bland JM, Altman DG. 1986. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1: 307-310

Bob-Manuel I, Didia B. 2008. Sexual dimorphism in foot dimensions among adult Nigerians. *Internet J Biol Anthropol* 3(1): (http://ispub.com/IJBA/3/1/3768)

Debat V, David P. 2001. Mapping phenotypes: canalization, plasticityand developmental stability. *Trends Ecol Evol* 16 (10): 555- 561

Gibson G, Wagner G. 2000. Canalization in evolutionary genetics: a stabilizing theory? *Bioessays* 22:372–380.

Gray P, Marlowe F. 2002. Fluctuating asymmetry of a foraging population: The Hadza of Tanzania. *Ann Hum Biol* 29: 495-501.

Hallgrimsson B, Willmore K, Hall BK. 2002. Canalization, developmental stability, and morphological integration in primate limbs. *Yearbook of Physical Anthropology* 45: 131- 158

Ibeachu PC, Abu EC, Didia BC. 2011. Anthropometric sexual dimorphism of hand length, breadth and hand indices of University of Port-Harcourt students. *Asian J Med Sci* 3(8):146-150.

Jantz RL, Webb RS. 1980. Dermatoglyphic asymmetry as a measure of canalization. *Ann Hum Biol* 7:489–493.

Karmakar B, Malkin I, Kobyliansky E. 2013. Inheritance of dermatoglyphic asymmetry and diversity traits in twins based on factor: variance decomposition analysis. *Coll Antropol* 37(2): 537-543.

Khanapurkar S, Radke A. 2012. Estimation of stature from the measurement of foot length, hand length and head length in Maharashtra region. *Ind J Basic & App Med R* 1(2):77-85.

Kieser JA, Groeneveld HT, Preston CB. 1986. Fluctuating dental asymmetry as a measure of odontogenic canalization in man. *Am J Phys Anthropol* 71:437–444.

Krishan K, Kanchan T, Passi N. 2011. Estimation of stature from the foot and its segments in a sub-adult female population of North India. *J Foot & Ankle R* 4:24.

Krishan K, Sharma A. 2007. Estimation of stature from dimensions of hands and feet in a North Indian population. *J Forensic Leg Med* 14:327-332.

Lee RD, Nieman DC. 2007. Nutritional Assessment. New York: McGraw Hill.

Livshits G, Kobyliansky E. 1989. Study of genetic variance in the fluctuating asymmetry of anthropometrical traits. *Ann Hum Biol* 16(2): 121-9.

Livshits G, Smouse PE. 1993. Multivariate fluctuating asymmetry in Israeli adults. Hum Biol 65(4): 547-78

Moudgil R, Kaur R, Menezes RG, Kanchan T, Garg RK. 2008. Foot index: is it a tool for sex determination? *J Forensic Leg Med* 15:223-226.

Palmer AR, Strobeck C. 1986 Fluctuating asymmetry: measurement, analysis, patterns. *Annu Rev Ecol Syst* 17, 391-421.

Palmer AR, Strobeck C. 1992. Fluctuating asymmetry as a measure of developmental stability: Implications of non-normal distributions and power of statistical tests. *Acta Zool Fenn* 191: 57-72.

Palmer AR, Strobeck C. 1997. Fluctuating asymmetry and developmental stability: heritability of observable variation vs. heritability of inferred cause. *J Evolution Biol* 10:39-49.

Palmer AR, Strobeck C. 2003. Fluctuating asymmetry analysis unplugged. In: Polak, M. (Ed.) *Developmental instability (DI): Causes and consequences.* Oxford: Oxford University Press.

Reddy BM. 1999. Fluctuating asymmetry and canalization: an appraisal based on a-b ridge counts among Indian populations with diverse backgrounds. *Am J Hum Biol* 11:367–381.

Ulijaszek S, Kerr D. 1999. Anthropometric measurement error and the assessment of nutritional status. *Brit J Nutr* 82:165-177.

Van Valen L. 1962. A study of fluctuating asymmetry. *Evolution* 16, 125–142.

Waddington CH. 1942 Canalization of development and the inheritance of acquired characters. *Nature* 150, 563–565

Waddington CH. 1953. Epigenetics and evolution. *J. Exp. Zool*. 7, 187–199

Wagner GP, Booth G, Bagheri-Chaichian H. 1997. A population genetic theory of canalization. *Evolution* 51:329–347.

Weyl, H. 1952. *Symmetry*; Princeton University Press: Princeton, New Jersey, USA.

Zeybek G, Ergur I, Demiroglu Z. 2008. Stature and gender estimation using foot measurements. *Forensic Sci Int* 181:54.e1– 54.e5