Association Between Digit Ratio (2D:4D) and Aggressiveness in a Community Population of Sekampung Udik, East Lampung, Indonesia

Salsabillah Annisa Ramadhani[1], *Winati* Nurhayu[1*], and *Gres* Maretta[1]

[1]Biology Study Program, Institut Teknologi Sumatera, South Lampung, 35365, Indonesia

Abstract. The digit ratio (2D:4D), defined as the relative length of the index (2D) to the ring finger (4D), reflects prenatal exposure to testosterone and estrogen. Higher prenatal testosterone exposure is associated with increased aggressiveness. Objective: This cross-sectional, community-based study aimed to examine the effect of the 2D:4D ratio on aggressiveness among communities in Sekampung Udik, East Lampung. Methods: A total of 300 respondents (male and female, aged 15–59 years) from three villages, Sidorejo, Pugung Raharjo, and Sindang Anom, were surveyed between January and March 2025. The 2D:4D ratio was measured using a digital caliper, whereas aggressiveness was assessed using the Buss and Perry Aggression Questionnaire. Data were analyzed using Linear Models (LM) in R version 4.4.2. Results: Results indicated that a lower left-hand 2D:4D ratio was significantly associated with higher levels of verbal aggressiveness ($p = 0.0184$), anger ($p = 0.0038$), and hostility ($p = 0.0155$). Demographic factors, including female sex, number of siblings, and domicile in Sidorejo Village, also significantly influenced aggressiveness. Conclusion: These findings suggest that both biological markers and sociodemographic factors contribute to the individual differences in aggressiveness. This study provides critical evidence for integrating biological and sociological perspectives in the study of aggressive human behavior.

1 Introduction

The digit ratio (2D:4D), the comparison between the lengths of the index finger (2D) and the ring finger (4D), is a stable marker influenced by prenatal exposure to sex hormones, particularly testosterone and estrogen. It is well-established that a lower 2D:4D ratio is associated with higher prenatal testosterone exposure [1, 2]. Consequently, this ratio exhibits sexual dimorphism, with males typically having a lower ratio than females [3]. This ratio is widely used as an indicator of biological predisposition and is associated with various physiological and behavioral traits in human [4].

Differences in the 2D:4D ratio have been extensively proposed as indicators of potential associations with human behavior, particularly aggressiveness. Aggressiveness, defined as behavior directed toward harming others through direct (physical and verbal violence) or indirect (anger and hostility) forms, is a complex trait influenced by both biological and environmental factors [5]. Several meta-analyses and studies, such as those by Manning [6] and Hönekopp and Watson [7], have consistently reported that individuals with a lower digit ratio tend to exhibit higher levels of aggressive behavior, both physically and verbally.

However, the most existing research linking 2D:4D to aggressiveness has been conducted on highly selective groups, primarily university students or athletes, which limits the generalizability of the findings. A significant gap remains in understanding this relationship within diverse, free-living, and community-based populations. Such settings are critical, as aggressive behavior in these communities, like that observed in Sekampung Udik District, is shaped not only by biological markers but also by complex social interactions and cultural norms [8]. Examining a community population allows for a more ecologically valid assessment of how biological factors interact with social dynamics to influence behavior.

This cross-sectional, community-based study was conducted in Sekampung Udik District, East Lampung Regency, focusing on three villages (Sidorejo, Pugung Raharjo, and Sindang Anom), chosen for their high population density [9] and the absence of prior data regarding aggressiveness. Therefore, the present study aimed to analyze the influence of the digit ratio (2D:4D) on the levels of aggressiveness among residents of Sekampung Udik District to provide new insights into the interplay between biological markers and social dynamics. This research is expected to inform strategies for preventing conflict and enhancing community well-being.

2 Materials and Methods

2.1 Study Location and Ethical Approval

This study was conducted from January to March 2025 in the Sekampung Udik District, East Lampung Regency, Indonesia (Fig. 1). Ethical approval was

*Corresponding author: winati.nurhayu@bi.itera.ac.id

obtained from the Health Research Ethics Committee, Faculty of Medicine, Universitas Gadjah Mada (approval no. KE/FK/0377/EC/2025).

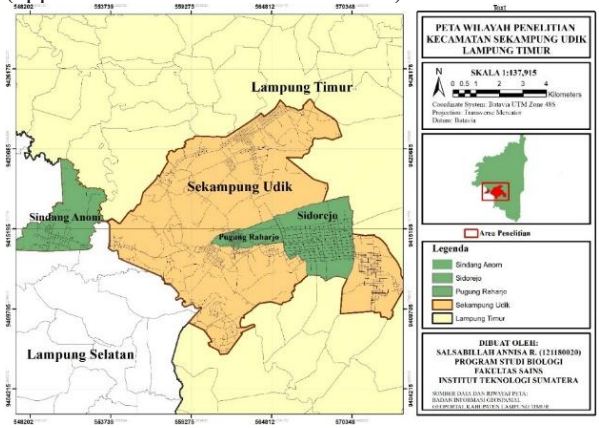

Fig. 1. Map of Sekampung Udik District, East Lampung Regency, Showing the Study Villages in green.

2.2 Sampling Method and Participants

This study employed a multi-stage sampling technique. First, cluster sampling was used to select three villages (Sidorejo, Pugung Raharjo, and Sindang Anom) based on the criterion of being the most populated in the district. Second, a convenience-based randomization approach was used for participant recruitment within each village. Participants were recruited by approaching permanent residents aged 15–60 years from public and residential areas.

Inclusion criteria were:

- Permanent residents born in the study area
- Physically healthy
- No history of finger injury or deformity

The sample size was determined using the Slovin formula (e = 0.10), resulting in 298 respondents: 100 from Sidorejo, 99 from Pugung Raharjo, and 99 from Sindang Anom.

2.3 Tools and Materials

The tools and materials used in this study included validated questionnaires, digital calipers, stationery, and mobile phone cameras.

2.4 Data Collection

The data collected consisted of demographic information, digit ratio (2D:4D) measurements, and aggressiveness scores. Participants were asked to provide demographic information, including sex, handedness, age, place of birth, residence, ethnicity, number of siblings, occupation, and income.

2.5 Aggressiveness Assessment

Aggressiveness was measured using the Buss and Perry Aggression Questionnaire, which consists of 29 items across four components:

- Physical aggression
- Verbal aggression
- Anger
- Hostility

Responses were rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The mean aggressiveness score was calculated for each respondent.

2.6 Measurement of Digit Ratio (2D:4D)

The digit ratio was measured using a digital caliper (accuracy 0.01 mm). The lengths of the index finger (2D) and ring finger (4D) were measured in both hands from the basal crease to the fingertip (Fig.2). To minimize observer bias and enhance reliability, all measurements were performed by a single trained researcher (blinded to the participant's aggression score). For quality control, each finger was measured twice, and the average value was used in the analysis. The digit ratio (2D:4D) was calculated as the length of the 2D divided by that length of the 4D.

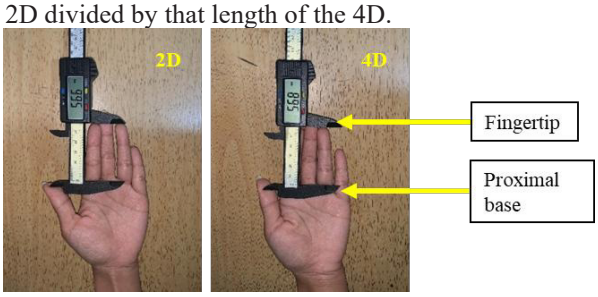

Fig. 2. Measurement of the index finger (2D) and ring finger (4D) for the finger digit ratio (2D:4D) using a digital calliper (Personal documentation)

Digit ratio classification [4]:

- 2D ≥ 4D: lower prenatal testosterone
- 2D = 4D: balanced hormone exposure
- 2D ≤ 4D: higher prenatal testosterone

2.7 Data Analysis

The effects of digit ratio (2D:4D) and demographic factors (independent variables) on aggressiveness score (dependent variable) were analyzed using Linear Models (LM) in R software version 4.4.2. A second-order polynomial term for the digit ratio (2D:4D) was included in the model to account for a potential non-linear relationship between the digit ratio and aggressiveness, as suggested by previous studies that hypothese optimal ranges or threshold effects. Diagnostic checks were performed to ensure the appropriateness of Linear Model assumptions for inference. Multicollinearity was assessed using the Generalized Variance Inflation Factor (GVIF), with all values well below the conservative threshold of five (Maximum GVIF = 1.83), indicating that multicollinearity was not an issue.

3 Result and Discussion

A total of 300 respondents participated in this study: 152 females (50.67%) and 148 males (49.33%). Participants were recruited from three villages in the Sekampung Udik District: Sidorejo, Pugung Raharjo, and Sindang Anom. Their ages ranged from 15 to 60 years, with a mean of 34 ± 13.16 years. The majority of participants were Javanese (79%) and primarily employed as housewives (29.67%). The detailed demographic characteristics are presented in Table 1.

Table 1. Demographic characteristics of study participants from Sekampung Udik District, East Lampung

Demographics		**Number**	**Percentage**
Sex	Female	152	50,67%
	Male	148	49,33%
Ethnicity	Javanese	237	79,00%
	Sundanese	31	10,33%
	Balinese	15	5,00%
	Lampungese	9	3,00%
	Palembangese	5	1,67%
	Piliangese	2	0,67%
	Padangese	1	0,33%
Handedness	Right	298	99,33%
	Left	2	0,67%
Occupation	Housewife	89	29,67%
	Entrepreneur / Self-employed	56	18,67%
	Student	54	18,00%
	Farmer	43	14,33%
	Laborer	40	13,33%
	Others	15	5,00%
	Civil Servant	3	1,00%
Income	Rp 0	143	47,67%
	Rp < Rp. 500.000	4	1,33%
	Rp. 500.001 – 1.000.000	11	3,67%
	Rp. 1.000.001 – 2.000.000	33	11,00%
	Rp. 2.000.001 - 3.000.000	46	15,33%
	Rp. 3.000.001 - 4.000.000	28	9,33%
	Rp 4.000.001 - 5.000.000	15	5,00%
	> Rp. 5.000.001	20	6,67%

Measurements of finger lengths revealed notable differences between males and females. Male respondents had longer index and ring fingers than female respondents on both hands. Consistent with sexual dimorphism in 2D:4D, males demonstrated lower 2D:4D ratios than females on the right hand (0.97 vs. 1.00) and left hand (0.97 vs. 1.00), indicating relatively higher prenatal testosterone exposure among males Table 2.

Table 2. Distribution of 2D:4D ratio in Sekampung Udik District

Measurement	**Sex (Mean ± SD)**		**Mean ± SD**
	Male	**Male**	
Right 2D (mm)	71,69 (±4,78)	66,94 (±4,79)	69.28 (± 5,34)
Right 4D (mm)	73,48 (±4,01)	67,22 (±4,81)	70,31 (± 5,43)
Left 2D (mm)	71,42 (± 4,08)	66,80 (±5,00)	69,08 (± 4,57)
Left 4D (mm)	73,65 (± 4,06)	66,98 (±4,86)	70,27 (± 5,58)
Ratio (2D:4D)	**Male (Mean ± SD)**	**Female (Mean ± SD)**	**Overall (Mean ± SD)**
Right	0,9676 (±0,04)	0.9962 (±0,03)	0.9821 (±0,04)
Left	0,9699 (±0,02)	0.9975 (±0,02)	0.9839 (±0,02)

Aggressiveness scores based on the Buss and Perry questionnaire also varied by sex. Males exhibited higher mean levels of physical and verbal aggression, whereas females showed slightly higher levels of anger and hostility. Across all participants, the domains with the highest mean aggressiveness were hostility and verbal aggression (Table 3).

Table 3. Sex-based differences in aggressiveness among residents of Sekampung Udik District

Aggressiveness	**Gender (Mean ± SD)**		**Overall (Mean ± SD)**
	Male	**Female**	
Physical	2,50 (±0,44)	1,99 (±0,40)	2,24 (±0,49)
Verbal	3,25 (±0,66)	2,93 (±0,63)	3,09 (±0,66)
Anger	2,81 (±0,56)	2,82 (±0,58)	2,82 (±0,57)
Hostility	3,11 (±0,52)	3,18 (±0,54)	3,15 (±0,54)

Regression analysis using a second-order polynomial model demonstrated that a lower left-hand digit ratio (2D:4D) was significantly associated with higher levels of verbal aggression ($p = 0.0184$), anger ($p = 0.0038$), and hostility ($p = 0.0155$). Although the association between left-hand 2D:4D ratio and physical aggression approached significance ($p = 0.0925$), it did not meet the statistical threshold ($\alpha = 0.05$). Adjusted $R^2 = 0.107$, indicating that the independent variables (left-hand 2D:4D and demographic factors) accounted for approximately 10.7% of the variance in aggressiveness. In contrast, the right-hand digit ratio did not exhibit a significant association with any aggression domains (Table 4).

Table 4. The effect of the digit ratio (2D:4D) on aggressiveness and associated influencing factors

Independent	Dependent	Estimate	Std.Error	T Value	P Value
Right-hand (2D:4D) ratio	Physical	-0,5567	0,5859	-0,950	0,3428
	Verbal	0,0348	0,7941	0,044	0,9650
	Anger	0,6129	0,6945	0,882	0,3782
	Hostility	0,0680	0,6525	0,104	0,9170
Left-hand (2D:4D) ratio	Physical	-0,8187	0,4851	-1,688	0,0925 ·
	Verbal	-1,5583	0,6574	-2,370	0,0184 *
	Anger	-1,6760	0,5750	-2,914	0,0038 *
	Hostility	-1,3150	0,5402	-2,434	0,0155 *
Demographic Factor		**Estimate**	**Std. Error**	**T value**	**P value**
Sex: Female		-0,2017	0,0477	-4,227	$3,16 \times 10^{-5}$*
Sidorejo Subdistrict		0,1170	0,0522	2,238	$2,60 \times 10^{-2}$*
Number of Siblings		-0.0417	0,0104	-3,979	$8,71 \times 10^{-5}$*

In addition to biological factors, several demographic variables significantly influenced aggressiveness. Female respondents exhibited lower aggressiveness scores than males ($p = 3.16 \times 10^{-5}$), and individuals with more siblings also showed reduced aggressiveness ($p = 8.71 \times 10^{-5}$). Furthermore, participants living in Sidorejo Village demonstrated higher aggressiveness levels than those living in Pugung Raharjo and Sindang Anom ($p = 0.026$).

3.1 Digit Ratio, Sex, and Aggressiveness

The measurements of finger lengths revealed the expected sexual dimorphism. Male respondents had longer index and ring fingers than female respondents, consistent with the general physical development influenced by sex hormones [9, 10]. Crucially, males demonstrated lower 2D:4D ratios than females on both the right hand (0.97 vs. 1.00) and left hand (0.97 vs. 1.00), aligning with global findings that link lower ratios to relatively higher prenatal testosterone exposure. Aggressiveness scores varied according to sex and domains. Males exhibited higher mean levels of physical and verbal aggression, consistent with established literature reporting that males tend to express more direct aggression [11]. In contrast, females showed slightly higher mean levels of anger and hostility. This supports the concept that females often express indirect or internalized forms of aggression, which may be moderated by social expectations and agreeable personality traits [11, 12].

3.2 Biological Predisposition: The Role of Left-Hand 2D:4D

The core finding of this study was the significant association between a lower left-hand 2D:4D ratio and higher levels of verbal aggression, anger, and hostility. The left hand's ratio is often considered a stronger indicator of prenatal hormone exposure than the right, as it may reflect a greater sensitivity to early hormone surges that influence the development of the right cerebral hemisphere, which is broadly linked to emotional regulation and aggressive impulse control [13]. The finding that the association was specific to the left hand and not to the right is consistent with this lateralized biological theory.

Furthermore, the model's predictive power (Adjusted $R^2 = 0.107$) suggests that while the left-hand 2D:4D ratio and demographic factors are statistically significant, they account for a small to moderate proportion (approximately 10.7%) of the total variance in aggressive behavior, leaving substantial room for environmental and psychological factors.

The observed link between low 2D:4D ratios and higher aggression is theoretically supported by neurodevelopmental mechanisms. High prenatal testosterone exposure is hypothesized to influence lateralization and maturation of key structures in the limbic system, such as the amygdala and hypothalamus, which are critical for regulating emotional and aggressive responses. While our study did not collect direct neurological data, the behavioral findings are consistent with the theoretical framework suggesting that prenatal hormone programming biases the threshold for aggressive expression.

The absence of a significant link between left-hand 2D:4D ratios and physical aggression in this community is important. Although hormonal influences may predispose individuals to aggression (as observed with verbal aggression, anger, and hostility), the sociocultural environment may restrict the expression of overt physical confrontation. This suggests a strong sociocultural moderation of a biological predisposition, where the inherent drive (linked to 2D:4D) is channeled into less visible but harmful forms of aggression (verbal and hostile behavior) due to community norms.

3.3 Sociocultural and Demographic Influences

Several demographic variables underscore the importance of the social context in shaping aggression. The finding that females exhibited lower overall aggression scores compared to males supports the biological influence of testosterone but is heavily reinforced by gender roles within this community.

Notably, individuals with more siblings demonstrated significantly lower aggressiveness. This highlights the impact of early socialization experiences, where increased exposure to conflict resolution and emotional self-regulation training within a large family setting serves as a protective factor, moderating biological tendencies toward aggression. The higher aggressiveness observed among residents of Sidorejo Village, potentially due to higher population density and the resulting competition for resources, further emphasizes that environmental pressures and social dynamics interact with biological predispositions to produce the final aggressive phenotype.

4 Conclusion

This cross-sectional, community-based study successfully demonstrated that a lower left-hand 2D:4D ratio is significantly associated with higher levels of verbal aggression, anger, and hostility among residents of Sekampung Udik District. This finding reinforces the hypothesis that prenatal androgen exposure is a biological predisposition that influence aggressive tendencies in adulthood. Crucially, the study also revealed that sociodemographic factors (female sex, number of siblings, and residential area) significantly contribute to variations in aggressiveness, highlighting the critical interplay between biological determinants and the social context in shaping aggressive behavior within a free-living community. The scientific contribution of this work lies in providing compelling evidence from a non-Western sample for integrating biological markers into comprehensive models of human behavior and encouraging a shift toward a robust biopsychosocial framework for understanding aggression.

These results have several important practical implications. The significant protective effect observed in individuals with more siblings suggests that early-life socialization that fosters conflict resolution and emotional self-regulation skills is a key intervention point. Furthermore, identifying villages with higher baseline aggression (such as Sidorejo) allows community leaders and health agencies to target prevention programs (e.g., psychoeducational training) more effectively. However, the interpretation of these findings must be considered in light of the methodological limitations of this study. Specifically, the cross-sectional design prohibits definitive causal inferences, and reliance on self-report questionnaires for aggression and manual measurement of the digit ratio may introduce bias. Therefore, future biopsychosocial studies should overcome these constraints by incorporating longitudinal designs, utilizing advanced digital measurement tools, and considering direct hormonal assays to enhance the validity and interpretive power of the relationship between biological markers and aggressive behavior across broader populations.

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Data supporting this research are available from the corresponding author upon reasonable request. WN conceptualized the study, supervised the research process, and conducted data analysis; SAR carried out field sampling and data collection; and GM assisted with data management and administrative support. All authors contributed to manuscript preparation and approved the final version of the manuscript.

References

1. V. G. Hapsari, W. Nurhayu, I. A. Khairani, A. Darmawan, G. Maretta, J. S. Mulyana, Digit ratio 2D:4D variation and the relationships to aggressivity in Sumatran Institute of Technology Students, in Proceedings of International Conference on Health, Science, and Environment, Advances in Biological Sciences Research, South Lampung, Indonesia, May 30 (2024). https://doi.org/10.2991/978-94-6463-431-0_11
2. J. Manning, L. Kilduff, C. Cook, B. Crewther, B. Fink, Digit ratio (2D:4D): A biomarker for prenatal sex steroids and adult sex steroids in challenge situations, Front. Endocrinol., 5, 9 (2014). https://doi.org/10.3389/fendo.2014.00009
3. E. Eklund, L. Ekström, J. O. Thörngren, M. Ericsson, B. Berglund, A. L. Hirschberg, Digit ratio (2D:4D) and physical performance in female olympic athletes, Front. Endocrinol., 11 (2020). https://doi.org/10.3389/fendo.2020.00292
4. E. Purwaningsih, The index-to-ring finger length ratio (2D:4D Ratio) incidence among Medical Faculty Students of YARSI University, Batch 2013-2014, Jurnal Kedokteran YARSI, 24, 1 (2016). https://doi.org/10.33476/jky.v24i1.134
5. J. T. Manning, B. Fink, Digit Ratio, in Encyclopedia of Evolutionary Psychological Science, (Springer International Publishing, Cham, 2018). https://doi.org/10.1007/978-3-319-16999-6_3829-1
6. B. Susantyo, Environment and personal aggressive behavior, Sosio Informa, 3, 1 (2017). https://doi.org/10.33007/inf.v3i1.389
7. Badan Pusat Statistik, Kecamatan Sekampung Udik dalam Angka 2024, (BPS Kabupaten Lampung Timur, Lampung Timur, 2024).
8. F. Syarif, Hubungan kematangan emosi dengan perilaku agresi pada mahasiswa warga asrama, Psikoborneo, 5, 2, (2017). http://dx.doi.org/10.30872/psikoborneo.v5i2.4364
9. E. Parslow, E. Ranehill, N. Zethraeus, L. Blomberg, B. von Schoultz, A. L. Hirschberg, M. Johannesson, A. Dreber, The digit ratio (2D:4D) and economic preferences: No robust associations in a sample of 330 women, J. Econ. Sci. Assoc. 5, 2 (2019). https://doi.org/10.1007/s40881-019-00076-y
10. R. S. Paluta, G. N. Tanudjaja, T. F. Pasiak, The relationship between height and foot length in Medical Faculty Students of Unsrat University,

Jurnal Biomedik, 5, 1 (2013). https://doi.org/10.35790/jbm.5.1.2013.2611

11. L. P. Kilduff, R. N. Hopp, C. J. Cook, B. T. Crewther, J. T. Manning, Evolutionary psychology digit ratio (2D:4D), aggression, and testosterone in men exposed to an aggressive video stimulus, Evolutionary psychology, 11, 5, (2013). https://doi.org/10.1177/147470491301100502
12. K. Björkqvist, K. Österman, Sex differences in aggression, In: J. Ireland, P. Birch, C. Ireland (eds), The Routledge International Handbook of Human Aggression (Routledge, 2018).
13. E. K. Silbergeld, J. A. Flaws, K. M. Brown, Organizational and activational effects of estrogenic endocrine disrupting chemicals. Cadernos de Saude Publica, 18, (2002). https://www.scielosp.org/article/ssm/content/raw/?resource_ssm_path=/media/assets/csp/v18n2/8278.pdf
14. R. Kaldewaij, S. B. J. Koch, W. Zhang, M. M. Hashemi, F. Klumpers, K. Roelofs, High endogenous testosterone levels are associated with diminished neural emotional control in aggressive police recruits, Psychol. Sci., 30, 8, (2019). https://doi.org/10.1177/0956797619851753
15. X. Jiang, X. Li, X. Dong, L. Wang, How the big five personality traits related to aggression from perspectives of the benign and malicious envy, BMC Psychol., 10, 1, (2022). https://doi.org/10.1186/s40359-022-00906-5