Research Article

Variability of Finger Ridge Density among Thai Adolescents

Somsong Nanakorn* and Wibhu Kutanan

Department of Biology, Faculty of Science, Khon Kaen University, Khon Kaen City 40002, Thailand

Abstract

Finger ridge density (RD) is the number of finger ridges that touch the diagonal line drawn between a square of 25 mm^2 which is placed on the core of the fingerprint image. It has been useful as a sex determination aid in forensic practice as its values are significantly higher in females than males. The present study was aimed at investigating the RD of Thai adolescents aged between 10 and 12 years old. Subjects were 130 schoolboys and 130 schoolgirls were randomly selected and signed informed consent forms prior to printing each individual's ten fingers by using the adhesive transparent tape technique. The Microsoft Word program was applied for precise counting of RD. The mean RD differences between left and right hands, boys and girls, radial and ulnar areas were statistically tested. The likelihood ratio was computed to obtain the probability inferences of sex, and posterior probabilities were estimated using Bayes' theorem. Results revealed as follows: (1) The mean RDs (ridges per 25 mm^2) of boys and girls were not significantly different across the radial (15.89 vs. 16.19, respectively) and ulnar areas (15.84 vs. 16.00, respectively). For each sex, mean RDs in the radial and the ulnar were not statistically different. (2) The mean RDs in both sexes were greater in the left hand fingers compared to the right hand, and were statistically significant only in girls. (3) For the ulnar area, the RD of 13 or less is most likely to be of from male origin and that of 17 or more has a low probability of being of female origin. Comparing the radial area, an RD of 14 or less has a low probability of being of male origin while a weak probability of the RD of 17 or more is most likely being of female origin.

Keywords: Fingerprint; Ridge density; Northeast of Thailand; Adolescents; Posterior probability

Introduction

Several empirical studies have been reported dermatoglyphics among various populations. Dermatoglyphics involve investigation of epidermal ridges and pattern types on human fingertips and palms which are useful in medical aids for diagnosis of genetic diseases [1,2]. It has been widely applied to bioanthropology and evolutionary biology to characterize populations and investigate the origin of human variability [3]. There are two types of dermatoglyphic studies, qualitative and quantitative. Qualitative dermatoglyphics is the investigation of fingerprint pattern types, where as finger ridge count on the fingerprint and *a-b* ridge count on the palmprint are the example of a quantitative dermatoglyphic study. Fingerprint pattern types and various specific characteristics, called minutia, have been utilized worldwide in forensic examinations for determination of individuality. High incidence of crime has made fingerprinting an important evidence for investigating officers. If the sex of suspects can be defined, their work scope could be narrowed down. To facilitate and shorten processes of investigations, finger ridge density (RD) becomes relevantly useful. The RD has been previously reported for forensic examinations aid in sex determination in multiple populations, for example Caucasian American, African American, Indian, Malaysian, Chinese, and Spanish ethnic groups. Higher RD in females than males in a given area was declared in earlier studies [4-7]. The RD, a number of finger ridges counted on the diagonal line drawn between a square of 25 mm^2 on the core of fingerprint image, varies among populations and sexes especially in people over 12 years old [8]. Hitherto, a limit number of RD observations has been reported in Thailand, thus this study intends to investigate the RD as well as evaluate the influential factors like sex, ages, and ethnicity in a sample of northeastern Thai adolescents.

Materials and Methods

Sample and fingerprint collection

School children residing in the northeastern of Thailand were informed and gave signed consent coupled with permission of their father or mother prior to printing individual's 10 fingertips. Two hundred and sixty subjects (130 boys and 130 girls aged between 10 and 12 years old) were randomly chosen from the school classes. Each individual's ten fingers were printed by using an adhesive transparent tape technique [9]. Research ethical approval was reviewed by Khon Kaen University Ethics Committee for Human Research.

Finger ridge density counting

Two counting areas using the radial area [3] coupled with the ulnar area [7] on a fingerprint image above the core were selected. A modified technique for RD counting was performed using the Microsoft Word program to construct two squares of 5×5 mm with a diagonal line drawn from each square on a spreadsheet. Images of 10 fingerprints were scanned in a picture format file and pasted on the sheet with two squares constructed. To facilitate more precise RD counting, each fingerprint image with those two squares was enlarged 500%. The finger ridges that touch the diagonal line were counted. This value represents RD of each fingerprint (Figure 1).

Statistical analysis

The RDs for the radial and ulnar areas of all 10 fingers of each subject were used to compute the mean for each area and each hand in both sexes. The mean RD for each area for all 10 fingers was also calculated in each individual. The differences between sexes were examined

for the radial and ulnar areas and mean for all 10 fingers. Data were statistically analyzed by obtaining total and group descriptive values. The studied areas (radial and ulnar) and sexes (male and female) were compared using the two-way analysis of variance (ANOVA) test. The differences between left and right hands as well as between radial and ulnar areas for each sex are estimated by independent t-test. All tests mentioned above were employed using SPSS version 17.0 [10]. The alpha level of significance was set at 0.05 for all statistical calculations.

The likelihood ratio (LR) was computed to obtain the probability inferences of sex, based on RD values [11]. Let FP be the fingerprint, C the male donor, and C' the female donor:

$$LR = \frac{\text{probability of the observed RD given that the FP originates from a male contributor } (C)}{\text{probability of the observed RD given that the FP originates from a female contributor } (C')}$$

The value of LR yields the strength of support for one of the hypotheses: C or C'.

Posterior probabilities i.e. $P(C/RD)$ and $P(C'/RD)$ were estimated using Bayes' theorem [8]. Information obtained from both LR and posterior probabilities are implied for determining the most likely hypothesis for a given ridge density $P(RD/C)$ and $P(RD/C')$. The prior probability of male $P(C)$ and female $P(C')$ are 0.5 by assuming that male and female are equally committed a crime.

Results and Discussion

The distribution of RD frequencies is shown in Figure 2. Variation in ridge count is restricted within a well-defined range. Of all the 2600 digits, there is no instance of a count less than 9 ridges per 25 mm², nor one exceeding 27 ridges per 25 mm². Ridge count in the radial area varying between 10 and 26 ridges per 25 mm² is in the same ranges as the ulnar area in which the count varies between 9 and 26 ridges per 25 mm².

In both boys and girls, the thumb and index fingers (1 and 2 fingers, respectively) of both hands show lower RD in the radial and the ulnar areas than middle, ring, and little fingers (3, 4 and 5 fingers, respectively), indicating the presence of thicker ridges in the thumb and index. Arranging the digits in order of increasing ridge count, the ranking is fingers 1, 2, 3, 5, 4 for the radial and the ulnar areas of the right and the left hands for both sexes. For each sex, RDs in the radial and the ulnar were not statistically different (P = 0.863 in boys; P = 0.294 in girls; Figure 3).

In the right and the left hands, the mean RD in the studied areas followed the same pattern as found for each finger (Figure 4). Mean RD in both sexes is greater in the areas of the left hand, thus showing

Figure 1: Two squares of 5X5 mm placing above the core of fingerprint image (ulnar loop and whorl) for counting the finger ridges that touch on the diagonal line to obtain the radial and ulnar finger ridge densities.
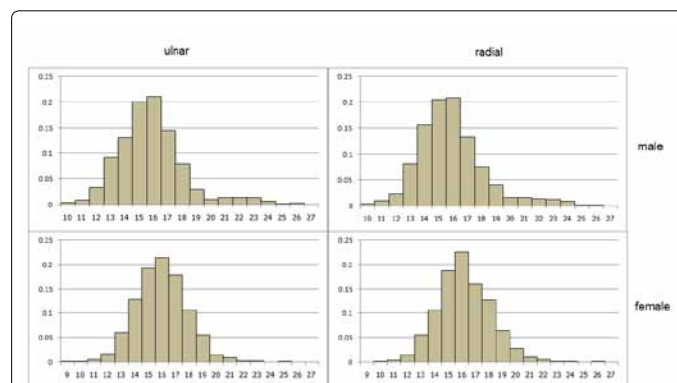

Figure 2: Frequency distribution of finger ridge density (RD) in boyss (n = 130) and girls (n = 130). RD in the radial area varying between 10 and 26 ridges / 25 mm² is in the same ranges as the ulnar area (9 and 26 ridges / 25 mm²).
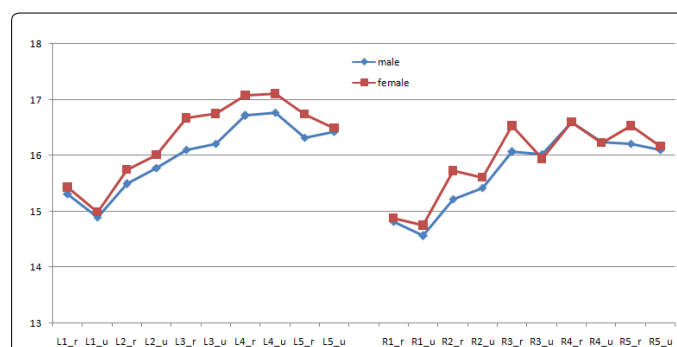

Figure 3: Mean finger ridge density (RD) of 10 fingers for each area. R, right hand; L, left hand; arabic number (1, 2, 3, 4, 5); fingers (thumb, index, middle, ring, little); u, ulnar RD; r, radial RD. In both sexes, the thumb and index fingers of both hands show lower RD in the radial and the ulnar areas than middle, ring, and little fingers. For each sex, the radial and the ulnar RDs were not statistically different (P = 0.863 in boys; P = 0.294 in girls).
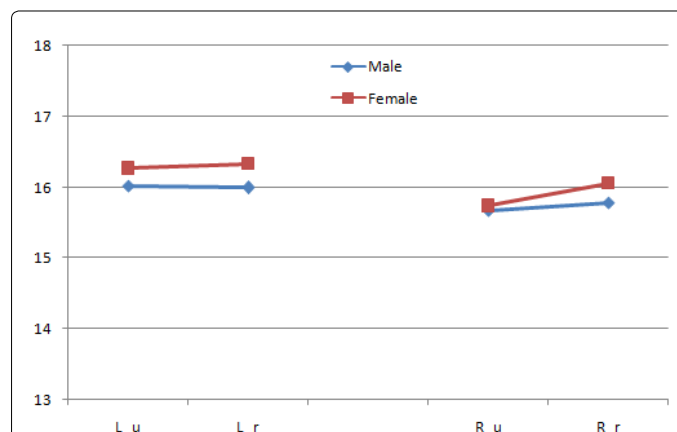

Figure 4: Mean finger ridge density (RD) of 10 fingers for each area for the left and right hands. L_u, ulnar RD of the left hand; L_r, radial RD of the left hand; R_u, ulnar RD in the right hand; R_r, radial RD of the right hand; Mean RD in both sexes is greater in the areas of the left hand, thus showing finer ridges than in the right hand with statistically significant difference only in girls (P = 0.25 in boys; P = 0.026

finer ridges than in the right hand. However, the differences were only statistically significant in girls (P=0.25 in boys; P=0.026 in girls).

The mean RD for all 10 fingers (Table 1) is not significantly different across the studied areas for both boys and girls (P=0.441). Gender differences is not statistically different in both the radial and the ulnar areas (P =0.124). The probabilities i.e., P(RD/C) and P(RD/C') were calculated by using the relative frequencies of RD from the samples. Then, the likelihood ratio and posterior probability using Bayes' theorem were obtained. Both values are used to identify the most likely sex, given the number of RD counted in a subject's sample (Tables 2 and 3). As shown in the ulnar area (Table 2), the posterior probability at a RD of 16 and 19 ridges per 25 mm^2 is equal between boys and girls, but at a RD of ≤ 13 ridges per 25 mm^2 boys show higher posterior probability than girls. This result only indicates that a RD of 13 ridges per 25 mm^2 or less is most likely being from male origin (P=0.61) and a RD of 17 ridges per 25 mm^2 or more has low probability being from female origin (P=0.55). In the radial area (Table 3), a fingerprint with RD of 14 ridges per 25 mm^2 or less has low probability being from male origin (P=0.6), whereas the weak probability of a RD of 17 ridges per 25 mm^2 or more is most likely being from female origin (P=0.55). However, it should be noted that the difference between male and female posterior probability at the RD from both radial and ulnar area is relatively low. Thus, for the real investigating process, this data might be hard to identify personal identification in crime. Since the subjects in this study aged from 10 to 12 years old, male and female do not differ. Our result is concordant to Gutierrez-Redomero et al. [12] which have been reported that female have higher RD than male when older than 12 years, but not when younger.

Table 4 shows variability of means RD across various populations [4-7, 13-14] including Thai adults [15] and Amerindian ethnic adolescents [16]. Females possess RDs statistically greater than those of males in any population except for Amerindian children [16]. Several reports have been suggested the RD differentiation among ages, sexes, and populations. Subjects in the present study and that of Amerindian children which are in the same age range showed significantly different mean RD. This might be caused by racial differentiation reflected the influence of environmental factors during pubertal growth promoting unequal epidermal ridges. Moreover, when comparing our result to Amerindian (Mataco-Mataguayo) adults, Chinese, Indian, and Malaysian populations, the differences of RDs were also found indicating the substantial influence of ethnic differentiation. Except for ages, sexes, and populations, dermatoglyphic region on finger [17] could be influenced a variability of epidermal ridge breadth [18]. The present study found that the thumb and index had a greater ridge breadth than that of other fingers, which is consistent with a study in Amerindian (Mataco-Mataguayo) adults. Moreover, mean RD of Thai children in this study and other Thai adults were compared to suggest age-related ridge variations. Mean RD of Thai boys seem to be greater than Thai adults (15.89 vs. 14.72 ridges per 25 mm^2, respectively), but probably not for girls, implying a variability of epidermal ridge breadth during the growth period. This result confirms the factors of age and ethnicity but not sex in governing RD in northeastern Thai adolescents.

statistics	total		boys		girls	
	ulnar RD	radial RD	ulnar RD	radial RD	ulnar RD	radial RD
N	260	260	130	130	130	130
mean	15.92	16.04	15.84	15.89	16.00	16.19
SD	1.72	1.71	1.96	1.90	1.44	1.48
minimum	12.50	12.70	12.8	12.6	12.5	12.7
maximum	23.90	23.80	23.6	23.7	23.5	23.8

Table 1: Descriptive statistics of RD in both boys and girls when subdivided by areas.

RD (ridges per 25 mm^2)	probability densities		likelihood ratio	posterior probability	
	male P(RD /C)	female P(RD /C')		P(C) = 0.5, P(C/RD)	P(C') = 0.5, P(C'/RD)
≤12	0.05	0.03	1.71	0.63	0.37
13	0.09	0.06	1.53	**0.61**	0.39
14	0.13	0.13	1.02	0.51	0.49
15	0.20	0.19	1.04	0.51	0.49
16	0.21	0.21	0.99	0.50	0.50
17	0.15	0.18	0.81	0.45	**0.55**
18	0.08	0.11	0.74	0.42	0.58
≥19	0.09	0.09	1.02	0.50	0.50

Table 2: Probability densities & likelihood ratios derived from observed RD in the ulnar area.

RD	probability densities		likelihood ratio	posterior probability	
	male P(RD /C)	female P(RD /C')		P(C) = 0.5, P(C/RD)	P(C') = 0.5, P(C'/RD)
≤12	0.04	0.02	1.53	0.61	0.39
13	0.08	0.06	1.42	0.59	0.41
14	0.16	0.11	1.48	**0.60**	0.40
15	0.20	0.19	1.09	0.52	0.48
16	0.21	0.22	0.93	0.48	0.52
17	0.13	0.16	0.83	0.45	**0.55**
18	0.07	0.13	0.59	0.37	0.63
≥19	0.11	0.12	0.93	0.48	0.52

Table 3: Probability densities & likelihood ratios derived from observed RD in the radial area.

populations	number of subjects	mean RD	
		male	female
Northeastern Thais * (10-12 years old)	260	15.89(1.80)	16.19(1.48)
Northeastern Thais adults[15]	461	14.72(1.21)	16.53(1.18)
Spanish[7]	200	16.23(1.39)	17.91(1.47)
South Indian[5]	500	12.80(0.90)	14.60(0.08)
South Indian[13]	550	12.47(1.49)	14.15(1.68)
Indian[14]	200	11.05(1.11)	14.20(0.63)
Chinese[6]	200	11.73(1.07)	14.15(1.04)
Malaysian[6]	100	11.44(0.99)	13.63(0.90)
African-American[4]	400	10.50(1.15)	12.61(1.43)
Amerindian (Mataco-Mataguayo)[15]	121	16.62(2.71)	17.82(2.87)
Amerindian (10-12 years old; Mataco-Mataguayo)[16]	66	20.90(NA)	20.27(NA)

*present study standard deviation is in parenthesis.   NA not available

Table 4: Comparison of mean RD among various populations.

Conclusion

The present study is the first report of RD among Thais adolescents aged between 10 to 12 years old residing in northeastern region of Thailand. The mean RD for all 10 fingers does not significantly differ between the ulnar and radial areas for both sexes. Finer ridges in the left hand than the right hand was observed in both sexes. The thumb and index had a greater ridge breadth than those of other fingers. The mean RD of female is greater than male but it is not statistically different. The identification of the most likely sex could not be succeeded since the relatively lower posterior probability. Means RD from various populations were compared to evaluate the existence of ages and racial differences in RD, confirming the observations of earlier researchers. Although the present study cannot predict sex determination by RD among Thai adolescent population, further studies on RD from subjects who older than 12 years old and from subjects belonged to different ethnicities in Thailand are proposed. The expectation from further results will be important tool for the forensic experts and law enforcement authorities.

References

1. Schaumann B, Alter M (1976) Dermatoglyphics in medical disorders. Springer-Verlag, New York.

2. Wertelecki W, Plato CC (1979) Dermatoglyphics: Fifty years later. Alan R. Liss, New York.

3. Meier R (1980) Anthropological dermatoglyphics: a review. Yrbk Phys Anthropol 23: 147-178.

4. Acree MA (1999) Is there a gender difference in fingerprint ridge density? Forensic Sci Int 102: 35–44.

5. Gungadin S (2007) Sex determination from fingerprint ridge density. Internet J Med Update 2: 1-6.

6. Nayak VC, Rastogi P, Kanchan T, Yoganarasimha K, Kumar GP, et al. (2010) Sex differences from fingerprint ridge density in Chinese and Malaysian population. Forensic Sci Int 197: 67-69.

7. Gutierrez-Redomero E, Alonso C, Romero E, Galera V (2008) Variability of fingerprint ridge density in a sample of Spanish Caucasians and its application to sex determination. Forensic Sci Int 180: 17-22.

8. Krishan K, Ghosh A, Kanchan T, Ngangom C, Sen J (2010) Sex differences in fingerprint ridge density--causes and further observations. J Forensic Legal Med 17: 172-173.

9. O'Leary E, Slaney J, Bryant DG, Fraser FC (1986) A simple technique for recording and counting sweat pores on the dermal ridges. Clin Genet 29: 122-128.

10. SPSS for Windows (2009) Release 17.0: SPSS Inc., Chicago, USA.

11. Nayak CV, Rastogi P, Kanchan T, Yoganarasimha K, Kumar GP, et al. (2010) Corrigendum to "sex differences from fingerprint ridge density in Chinese and Malaysian population" [Forensic Sci. Int. 197(2010) 67-69]. Forensic Sci Int 202: 112.

12. Hedrick PW (2011) Genetics of Populations. 4th ed. Jones and Bartlett Publishers, USA.

13. Nithin MD, Manjunatha B, Preethi DS, Balaraj BM (2011) Gender differentiation by finger ridge count among South Indian population. J Forensic Leg Med 18: 79-81.

14. Nayak VC, Rastogi P, Kanchan T, Lobo SW, Yoganarasimha K, et al. (2010) Sex differences from fingerprint ridge density in the Indian population. J Forensic Leg Med 17: 84-86.

15. Promponmaung P, Nanakorn S (2012) Finger ridge density of northeast Thai population. KKU Sci J 40: 52-58.

16. Gutierrez-Redomero E, Alonso MC, Dipierri JE (2011) Sex differences in fingerprint ridge density in the Mataco-Mataguayo population. Homo 6:487-499.

17. Ohler EA, Cummins H (1942) Sexual differences in breadths of epidermal ridges on the fingertips and palms. Am J Phys Anthropol 29: 341-362.

18. Dillon YK, Haynes J, Henneberg M (2001) The relationship of the number of Meissner's corpuscles to dermatoglyphic characters and finger size. J Anat 199: 577-84.