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ORIGINAL ARTICLE

Determination of sex difference from fingerprint ridge density in northeastern Thai teenagers

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Abstract: Although, there has already been much research on the differences between sexes in fingerprint ridge density and its variability in the Thai population, such studies have not included native northeastern Thais aged between 14 and 24 who are descended from northeastern Thai ancestry. This study intends to determine the topological, age-grouping and sexual differences in fingerprint ridge density (RD) in such populations. Fingerprints were collected from 353 unrelated volunteers (191 males and 162 females) and classified into three groups, that is, group A (total subjects), group B (14–18 years old) and group C (18–24 years old). RD was assessed for two topological areas, radial and ulnar. Significant differences between genders and age groups were obtained in both counting areas. Females exhibit higher RD i.e. narrower ridges, than males. A decrease in RD values with increasing age was also detected. The RD threshold for discrimination of sexes, computed based on Bayes' theorem, was achieved in all groups and counting areas, enabling its use in forensic investigation.

1. Introduction

Fingerprints, composed of ridges and furrows, are one of the dermatoglyphic traits that can be used for identification of an individual. The formation of the ridges is governed by a multitude of genes and the environment of the embryo during its first month of development, in other words the content of the amniotic fluid.[1,2] Once created, the ridges do not transform anymore throughout the lifetime except in cases of injury. Although the ridge number in a fingerprint is not age-dependent, the ridges grow further apart with an increasing age as the body size increases.[3–6] Generally speaking, the study of dermatoglyphics is either qualitative or quantitative. Qualitative dermatoglyphics focuses on, among other things, patterns of fingerprints and types of minutiae; while, ridge count and finger ridge density (RD) are examples of the fingerprints' quantitative study.

Fingerprints are unique in each individual even in identical twins they are not identical.[7] Thus, fingerprint pattern types and various specific characteristics have been utilized worldwide for personal identification. Latent fingerprints are a primary evidence that investigating officers need to collect at the crime scene.

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The study of RD has been incessantly reported in multiple populations for forensic applications.[8–16] One study reported RD evaluation in the northeast of Thailand[17]; however, teens were not among its subject groups. Based on reports in 2013 by the Department of Juvenile Observation and Protection, as they have been involved in a large number of cases in Thailand (36,763 cases), there is an urgent need for RD evaluations among the teenagers. The term teenager is one that, the World Health Organization defines as those who are aged between 15 and 24, while the Thai Royal Act and the Thai Royal Institute Dictionary defines as those whose ages range from 15 to 18 and 14 to 18, respectively.[18] Combining all three definitions, we set the age group of the teenagers in this study as between 14 and 24 years.

Our main objectives in this study are to compare the RD difference between male and female teenagers and within the same sex if RD differs between the younger group of 14–18 years old and the older one of over 18 up to 24 years of age. We also compared our RD results to the existing database of other populations.[17] Although ridge formation was determined by genes and the content of the amniotic fluid, ridge number has been proven to be highly genetically inherited, with as much as 90–95% contribution by the genes.[19,20] Consequently, if populations are genetically distinct, RD is likely different between then.

2. Materials and methods

Since the present study involved underaged individuals, on top of the informed consent, those under 18 years of age must have their participation approved by their parents. To qualify as a Northeasterner for our study, unrelated individuals (by at least two generations) must be descended from the northeastern Thai ancestry and they must come from a family where all members are able to speak the northeastern Thai dialect. This research protocol was approved by the Khon Kaen University Ethics Committee for Human Research. In total, fingerprints from all fingers of 353 subjects (191 males and 162 females) were obtained, using an ink pad and rolled ink print technique.[21]

Generally, fingerprint ridge density is acquired from a number of ridges over an area of $5 \times 5\ mm^2$ based on the method of Acree.[8] Our study slightly modified this method[8] and that of the counting portion described by Gutierrez-Redomero et al.[6] We constructed two squares of $5 \times 5\ mm^2$ each and placed them on the second ridge above the central core in both the radial and ulnar areas (Fig. 1). In each square ridges were counted from one corner to the diagonally opposite corner. Dots were not counted, while forks and lakes were counted as two ridges. To count the ridges[22], each fingerprint on a collected fingerprint card was scanned to an image format file. The image was then superimposed on the two squares of $5 \times 5\ mm^2$, each with one diagonal line, which were constructed on a spreadsheet using the Microsoft Word program. The superimposed images were enlarged five times for more precise ridge counting.

In the statistical analyses, the RD values for the radial and ulnar areas of all 10 fingers were calculated means in 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 computed. The comparison of means for the radial and ulnar areas in each hand and means for all 10 fingers among genders was executed using independent *t*-test as embedded in SPSS version 17.0.[23]

The probability density in male (C) and female (C') in each given RD density was calculated by observed RD and then these two values in each given RD density were used to compute the likelihood ratio (LR). Let RD be the ridge density, C the male donor, and C' the female donor:

$$\mathrm{LR} = \frac{\text{probability of the observing a given ridge density that belongs to male contributor}\,(C)\,\text{or}\,P(\mathrm{RD}/C)}{\text{probability of the observing a given ridge density that belongs to female contributor}\,(C')\,\text{or}\,P(\mathrm{RD}/C')}$$

The strength of support for one of the hypotheses: C or C' was indicated by LR value. Posterior probabilities i.e. $P(C/\mathrm{RD})$ and $P(C'/\mathrm{RD})$ were computed using Bayes' theorem as expressed in the following equation.

$$\text{Posterior probability} = \frac{P(C) \times P(\mathrm{RD}/C)}{P(C) \times P(\mathrm{RD}/C) + P(C') \times P(\mathrm{RD}/C')}$$

Figure 1 Two squares of $5 \times 5\ mm^2$ each were placed just above the core of a fingerprint image. For each square, a diagonal line was constructed. Ridges passing through the line were counted for the calculation of ridge density.