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Assessment of the methodology for estimating ridge density in fingerprints and its forensic application

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ABSTRACT

In recent times, some studies have explored the forensic application of dermatoglyphic traits such as the epidermal ridge breadth or ridge density (RD) toward the inference of sex and population from fingerprints of unknown origin, as it has been demonstrated that there exist significant differences of fingerprints between sexes and between populations. Part of the population differences found between these studies could be of methodological nature, due both to the lack of standardisation in the position of the counting area, as well as to the differences in the method used for obtaining the fingerprint. Therefore, the aim of this study was to check whether there are differences between the RD of fingerprints depending on where the counting area is placed and how the fingerprints are obtained. Fingerprints of each finger were obtained from 102 adult Spanish subjects (50 females and 52 males), using two methods (plain and rolled). The ridge density of each fingerprint was assessed in five different areas of the dactylogram: two closer to the core area (one on the radial and the other on the ulnar side), two closer to the outermost area of each of the sides (radial and ulnar), and another one in the proximal region of the fingertip. Regardless of the method used and of the position of the counting area, thumbs and forefingers show a higher RD than middle, ring, and little fingers in both sexes, and females present a higher RD than males in all areas and fingers. In both males and females, RD values on the core region are higher than those on the outer region, irrespective of the technique of fingerprinting used (rolled or plain). Regardless of the sex and location of the count area (core or outer), the rolled fingerprints exhibit RD greater than that of the plain ones in both radial and proximal areas, whereas the trend is inverted in the ulnar area, where rolled fingerprints demonstrate RD lesser than that of the plain ones. Therefore, in order for the results of different studies to be comparable, it is necessary to standardise the position of the count area and to use the same method of obtaining the fingerprint, especially when involving a forensic application.

1. Introduction

In the field of human biology, dermatoglyphic studies have traditionally been used for characterizing human populations, at both intra- and intergroup levels, as much for healthy populations [1–4] as for pathological ones [5–7]. In the scope of forensic science, fingerprints have been used for personal identification for over a century [8–17].

Dermal papillae ridges have multifactorial polygenic inheritance, in which environmental influence is limited to the first months of prenatal life [18,19]. Once formed, and in the absence of injury, these ridges remain essentially unchanged throughout the lifetime of the individual. Consequently, the number of epidermal ridges is independent of age, and the ridges will have to increase their size (width), without adding new ridges, to fit the whole body growth and, in particular, the hand and foot growth [20–24]. Some of the dermatoglyphic traits, such as ridge number, are highly heritable since they are almost fully genetically determined (90–95%), whereas other traits, such as the minutiae, are largely determined by the environment during prenatal development [25].

Regarding epidermal ridge breadth or thickness, although few studies have assessed their variability in human populations, these studies have revealed the presence of topological, finger, and sex variability, as well as population differences [26–34].

Some studies have explored their forensic application toward the inference of sex, from fingerprints of unknown origin [35–42]. The only study to date in the North American population has been described by Acree [35] and was carried out on samples of the Caucasian and African-American populations. For the South American population, Gutiérrez-Redomero et al. [42] have published a study on the

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Argentinian population. The Spanish population has been studied by Gutiérrez-Redomero et al. [37], while Gungadin [36], Nithin et al. [40], Nayak et al. [38,39], and Agnihotri et al. [41], have analysed Indian, Chinese, Malayan, and Indo-Mauritian populations, respectively.

Part of the differences found between these studies could be of methodological nature, due both to the lack of standardisation in the location of the counting area and to the differences in the technique for obtaining the fingerprint. Thus, although the ridge density (RD) assessment is always carried out on the same 5 × 5 mm area designed by Acree [35], the position of the counting area has only been standardised by Gutiérrez-Redomero et al. [23,37,42,43] and Krishan et al. [44]. Furthermore, in some cases, the fingerprint has been obtained by rolling the finger onto a surface (a "rolled" fingerprint) while in others, the finger is pressed down on a flat surface (a "plain" fingerprint) [45]. From all the above follows the need to check whether there are differences in the RD depending on where the counting area is placed and how the fingerprint is obtained (rolled or plain).

2. Materials and methods

The study sample consisted of 102 healthy individuals (50 females and 52 males) who were studying at the Department of Life Sciences of the University of Alcalá (Madrid, Spain). All subjects included in the study were native to this country: they were born in Spain, and their parents and grandparents were also born in Spain, mainly in the central and southern regions. Since ridge width varies with age during the growth period all selected individuals had completed their period of growth and were between 18 and 34 years of age.

The technique used in obtaining the fingerprints was a variation of the adhesive paper and graphite method [46], developed by Gutiérrez-Redomero et al. [42]. This technique involves the use of graphite powder to stain homogeneously the fingertip papillae ridges. The graphite powder is then deposited from the fingertips onto the sticky side of a label of the appropriate size. Then, these labels are affixed to a transparent acetate sheet that has been designed with scales and grids in order to allow that each sheet may contain each of the 10 fingerprints obtained from an individual. By using this technique, a mirror image of the fingertip surface is achieved, similar to that obtained with the classic ink method. The fingerprints of each individual were taken twice, firstly by rolling the fingertip in ulnar to radial direction, and then a second time by pressing down the fingertip on a flat surface. As a final result, 20 fingerprints per subject were obtained, 10 rolled and 10 plain (Fig. 1). This allowed the analysis of 1020 rolled and 1020 plain fingerprints in order to compare the RD presented between both methods.

The assessment of the RD was carried out by means of counting the ridges found diagonally within a 5 mm × 5 mm square, known as count area, which, according to the method described by Acree [35],

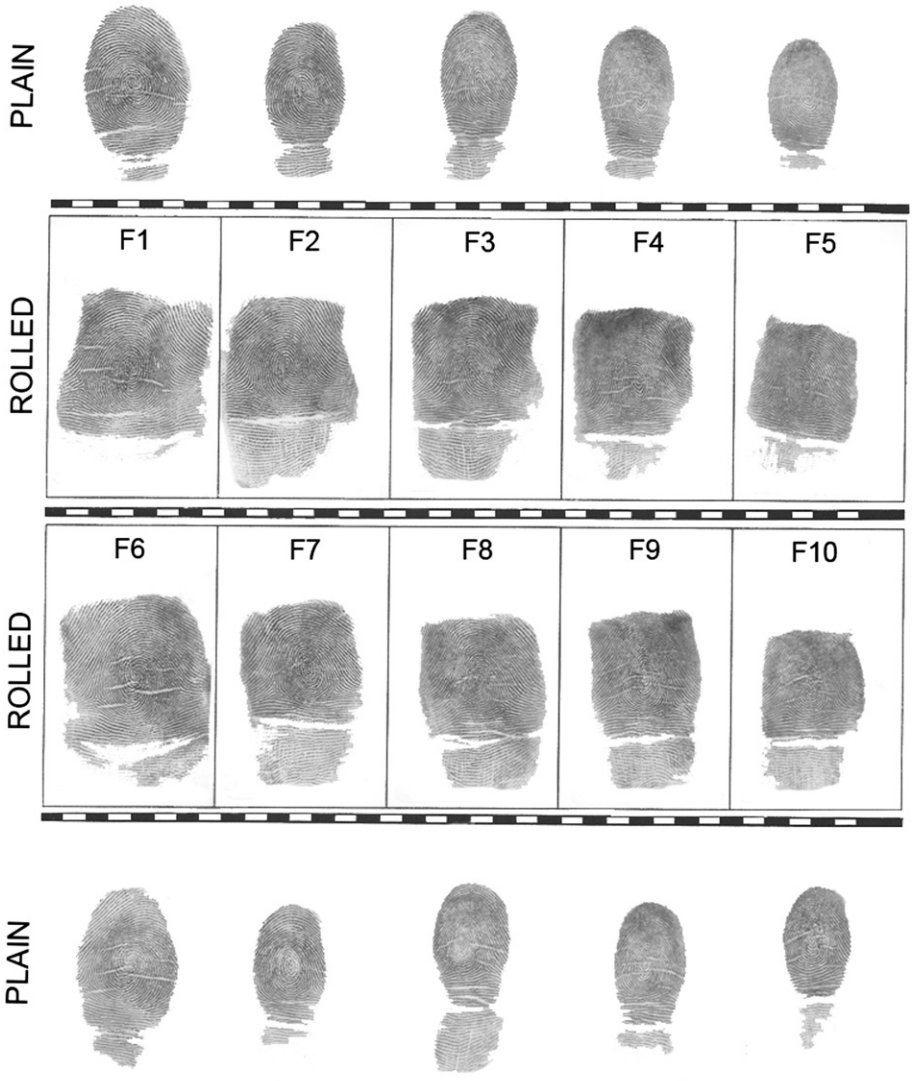

Fig. 1. Transparent acetate sheet showing the 20 fingerprints obtained per subject: 10 rolled and 10 plain. Fingers: from F1 (right thumb) to F10 (left little finger).