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Distribution of the *minutiae* in the fingerprints of a sample of the Spanish population☆

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ABSTRACT

One of the fundamental aspects of the process of identification through fingerprints is the comparison of the *minutiae* between the fingermark obtained at the scene of the crime and the suspect's corresponding finger. There is no scientific basis in this process that allows the use of numerical standards, such as those kept in different countries, to obtain the identification. The recent mistakes made in the field of dactyloscopy, together with the growing rigor and scrutiny that forensic evidence undergoes in the legislative and scientific areas, have resulted in the need to reconsider some of the basic principles that support this discipline. A probabilistic estimation of the evidential value is especially necessary; therefore, it is indispensable to know and quantify the variability of the features used in the identification process.

The sample studied for this research was obtained from 100 Caucasian men and 100 Caucasian women from the Spanish population, which amounts to a total of 2000 fingerprints. The different types of *minutiae* were located, identified, and quantified visually on the fingerprint, in four sectors, and inside and outside of a circle, whose radius cut, perpendicularly, fifteen ridges starting from the center cut of the axes that defined the sectors. According to the results obtained in this study, through dactyloscopic identification, the weight of the evidence of a *minutia*, such as the ridge endings, with frequencies between 55% and 65%, according to the area and gender evaluated, cannot be the same as that of a bifurcation or convergence, with frequencies of 13–18% or those of other *minutiae* that show frequencies lower than 3%. The significant differences found in the topological distribution of the endings, bifurcations, and convergences show the need to take into account, for its demonstrational value, the finger area in which they are evaluated. The significant association observed between the types of *minutiae* and the different fingers revealed a greater frequency of endings on the thumb and index fingers, and bifurcations and convergences on the middle, ring, and little fingers.

1. Introduction

Criminalistics is defined as the science of identification within the context of crime. It includes dactyloscopy, which is built upon three basic principles: (1) the durability of the papillary ridges, (2) the individuality of morphological and topological characteristics, and (3) the capacity to achieve individualization following a systematic comparison of the prints left by the skin, as long as they possess both quality (clarity) and quantity (surface) of detail [1].

Recent mistakes made in the field of dactyloscopy (a discipline with a high standing in the core of Forensic Sciences), together with the growing rigor and scrutiny that forensic evidence is now undergoing in the legislative area (for the most part as a consequence of the *Daubert* recognition admissibility criterion), have resulted in the need to reconsider some of the basic principles that support these disciplines in their recognition as sciences [1–10]. In March, 2009, the *National Academy of Sciences* issued a report with major international repercussions entitled "Strengthening Forensic Science in the United States: a path forward" [11]. It revealed the deficiencies in some of the disciplines used in this field, the need to establish and standardize the techniques applied, as well as the need to carry out basic research that will grant these disciplines the scientific recognition that will allow their use with all the necessary guarantees of validity and reliability.

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These types of deficiencies do not seem to be present in "DNA typing" as it is practiced today. In fact, DNA typing is presented as an example to be followed by the traditional forensic sciences, at least in three important aspects, as stated by Saks and Koehler [6]: "First, DNA typing technology was an application of knowledge derived from core scientific disciplines. This provided a stable structure for future empirical work on the technology. Second, the courts and scientists scrutinized applications of the technology in individual cases. As a result, early, unscientific practices were rooted out. Third, DNA typing offered data-based, probabilistic assessments of the meaning of evidentiary "matches". This practice represented an advance over potentially misleading match/no-match claims associated with other forensic identification sciences."

Dactyloscopy could also fulfill the same requirements currently achieved in DNA typing. With respect to the first aspect, disciplines such as physical anthropology, human genetics, and clinical genetics, that have a solid scientific structure, have presented numerous empirical studies concerning the diverse features present in the papillary ridges, mainly the finger and palm. These include aspects such as the frequency of the general pattern types (arch, loop and whorl) and the partial (RC) or total (RCT) ridge count, as well as its variability, its heredity in different human populations, and its manifestation in different syndromes and pathologies ([12–24] see bibliography checklist in [25–27]). Therefore, nearly all of the research into friction skin and its morphological characteristics has traditionally been approached through the field of physical anthropology, independently from the application of this knowledge. The information provided by these studies, in conjunction with more specific ones that need to be carried out concerning some of the characteristics used in the process of identification (i.e. *minutiae*, pores, and their relative configurations), should be used to build a solid base to support the process of identification through fingerprints. Regarding the second requirement, scientists as well as courts must make an effort to eradicate the clichés that have been maintained, without scientific basis, for a long time. A clear example is the erroneous idea of the infallibility of application of the dactyloscopy technique [2,28–35]. Lastly, with respect to the third requirement, studies on fingerprints applied in forensic identification, such as those by Galton, Henry, Balthazard, Roxburgh, Amy, Trauring, Kingston, Osterburg et al., Stoney and Thornton, Champod and Margot, Meagher et al. (see Stoney [36,37]), Neuman et al. [38,39], or Santamaría [40] in the Spanish population, have been considerably scarcer than those developed in the field of human biology. We think that the copious dactyloscopic databases, once analyzed to quantify the biological variability of the assessed features, could be used to develop a probabilistic calculation of identity to increase the weight of the evidence of fingerprints. Thus, it is essential to know the frequency of the most relevant characteristics in different human populations for the process of identification by fingerprints and, particularly, the characteristics related to the *minutiae* [6,10,11,41]. Paradoxically, few studies exist on this subject, but they are the ones needed to strengthen the process of identification within the current context [7–9,11,37–39,42–44].

For this reason, the aim of the present paper has been the further development of this line of research, by carrying out a qualitative and quantitative evaluation of the variability of the *minutiae* in a sample of the Spanish population.

2. Materials and methods

The study sample consisted of 200 inked ten-print records of 100 Caucasian men and 100 Caucasian women from the Spanish population (all born in Spain). This amounted to a total of 2000 fingerprints that were digitalized on the premises of the General Commissary of Scientific Police of Madrid. Each true color (24bit) jpg image had a size of 1496 × 2002 pixels, with a resolution of 200 ppi or 79 pixels/cm.

A preliminary analysis was carried out to establish the measurement accuracy of the dactyloscopic technique with respect to the interpretation of the *minutiae* and to minimize the possible effect of connective ambiguities on the evaluation of the *minutiae* of our work. To do this, we obtained from the distal phalanx of ten fingers from ten people (a total of 100 digits) the direct photographs of the clean fleshy parts of the fingers, the photographs of the said fleshy parts after being doused in graphite and/or ink, and the photographs of the fingerprints imprinted on paper (Fig. 1). The fingerprints obtained with either graphite or ink reflected the morphology of the papillary ridges with sufficient accuracy.

Subsequently, we analyzed various aspects of the variability of the *minutiae* in the Spanish study population, including frequency of appearance, distribution on the area of the fingerprints, and association with the pattern type (arches, loops, and whorls).

The identification of the *minutiae* was based on the classification used by the Spanish Scientific Police [45] (Fig. 2a). The definitions of some of the *minutiae* used

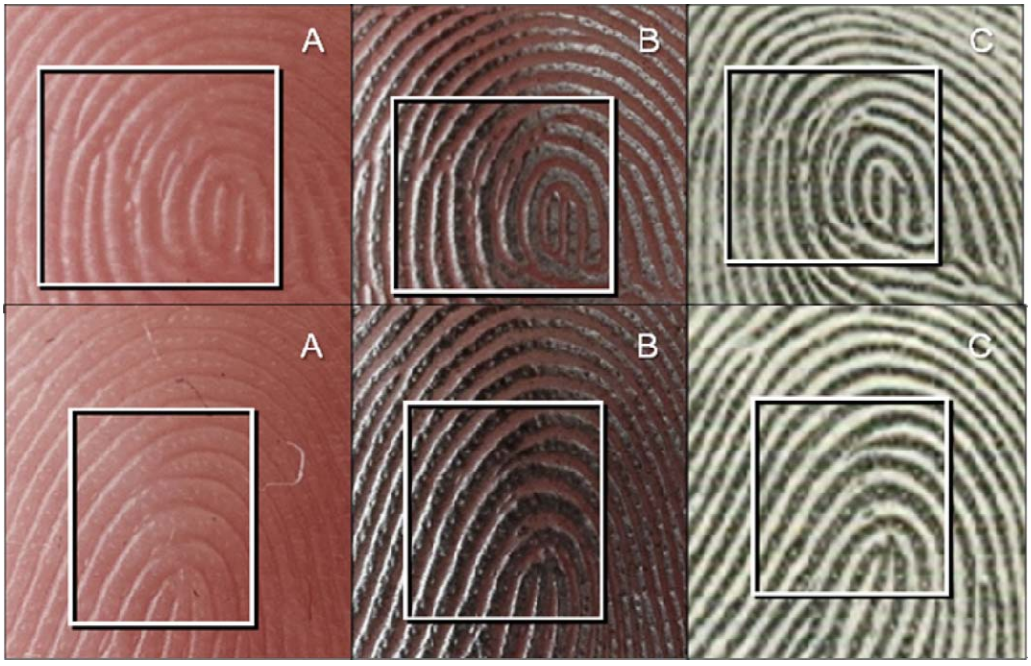

Fig. 1. A: Dactyl papillary ridges, B: papillary ridges doused with graphite, C: fingerprints.