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Biological variability of the minutiae in the fingerprints of a sample of the Spanish population

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Abstract

The minutiae, a term coined by Galton to refer to the small peculiarities present along the length of every isolated ridge, or characteristic points, a term used primarily by the Spanish Police Scientists, have an inter- and intrapopulation variability which has not been extensively studied. However, these peculiarities constitute the bases for the fingerprint identification of individuals in the field of criminology. Using the adhesive paper and graphite method, the fingerprints of 200 students, 100 males and 100 females, with ages ranging between 20 and 35, have been taken at the University of Alcala (Madrid). From this sample, the distal phalanx of the index finger of the right hand has been studied. The total count of the minutiae, as well as that of each different type, was made of the entire print area, and inside and outside of a circle with a radius of 18 ridges. The highest frequencies were of ridge endings, followed by bifurcations and convergences, all others appearing with frequencies of lower than 5%. The distribution of the minutiae was not homogeneous for the area of the fingerprint (inside and outside the circle). In the study of minutiae statistically significant differences were found between the sexes, and between the different types of general pattern (arches, loops, and whorls).

Keywords: Minutiae; Fingerprints; Dermatoglyphics; Forensic anthropology; Spain

1. Introduction and objectives

The identification of individuals based on their fingerprints is common practice in forensic laboratories and identification laboratories throughout the world and has been accepted in courtrooms for more than a century. One of the basic aspects of the identification process using fingerprints is the comparison of the minutiae or characteristic points of the latent impression obtained at the scene of a crime and the fingerprint of the suspect. Fingerprint identification is based on two premises. (a) Permanence: The basic characteristics of the dermal ridges do not change over time. (b) Individuality: The characteristics of the dermal ridges are unique to each individual. Whilst the validity of the first premise has long been established, the second premise has not been validated, as the underlying scientific bases for the individuality of the dermal ridges has not been formally established.

The question of the individuality of fingerprints was first tackled by Galton in 1892 [1]. Since then different models for establishing a probabilistic estimate of fingerprint individuality have been proposed, such as those put forward by Henry, Balthazard, Roxburgh, Amy, Trauring, Kingston, Osterburg et al., Stoney and Thornton, Champod, Meagher et al., the validity of which have been analysed and criticized in later works [2,3]. Each of these models uses in its analysis the probability of the apparition of minutiae in the fingerprints without going into detail about their variability thus leaving the problem unresolved.

From an identification point of view, the minimum number of minutiae needed to establish the identity of an individual (numerical standard) varies considerably between the criminal laboratories of different countries. This variability is due to the fact that the minimum number of minutiae needed to prove identity has not been rigorously established [3,4–9].

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The nature and variability of configurations of epidermal ridge minutiae is of direct forensic science significance in the evaluation and comparison of fingerprints, particularly of partial fingerprints [2].

Unfortunately, due to the absence of systematic studies of their distribution and variability on the dermal ridges, our present knowledge of these dermal papillae characteristics is insufficient, and so important aspects of their biology and genetic make up are unknown [2,10–12].

One of the problems with approaching the study of these dermatoglyphic peculiarities is the different classification for them that exist. Although the different attempts that have been made to classify the minutiae agree about the principal types [2,8,12–22], they have not obtained the necessary agreement within the scientific community which would allow for the systemization of the study; a situation that must change so that the samples and results of the different populations can be compared.

In this work we have studied the following aspects of the variability of the minutiae in a sample of the Spanish population; the frequency with which they appear, their distribution over the entire fingerprint, gender differences and the relation to the general fingerprint pattern (arch, loop and whorl). The idea is to increase the knowledge of said variability and so improve its application, as much in the field of Human Biology to characterise different populations, as in the field of Forensic Science, in its application in the identification of individuals.

2. Material and method

The material used in the present study was obtained from the fingerprints of the index finger of 200 individuals (100 male and 100 female) with ages ranging between 20 and 35. The samples were taken in the Physical Anthropology laboratory of the University of Alcalá (Madrid). The samples were obtained by means of the adhesive paper and graphite method [23]. Therefore, when comparing those minutiae whose classification depends on the direction of the turn, which is the case with bifurcations and convergences, we must take into account that the image of the fingerprint we see using this method is not a mirror image as occurs with that obtained using ink. As the samples in most studies are obtained using ink, the data for these two types of minutiae have been changed and presented in such a way as to make them directly comparable with those obtained using ink.

In this study the classification used by the Spanish Police Scientists has been used for the different types of minutiae or characteristic points and their varieties, Tables 1 and 2. The varieties assessed in the breaks, and the opposed bifurcations were included by the authors as an amplification of those considered by the Spanish Police Scientists. The minutia count, designed according to the method described by Okajima, was made using amplified images of the fingerprints, both the entire fingerprint and inside and outside a circle with an 18 ridge radius [19]. Carried out this way, the count allowed us to establish the different topographical features that exist for the number and type of minutia between the central area and the periphery and, depending on the principal type of pattern and the gender of the subject, compare them. As the diameter of the circle always cuts across 36 ridges (18 ridges are on the side defined by the figure), we eliminate any possible differences caused by the size of the finger and the ridges. The count was carried out jointly by an expert dactyloscopist and a physical anthropologist (Fig. 1).

The sample was statistically analysed using the Statgraphics Plus 5.1, program, which estimates the average total number and frequencies of the each minutiae type for the whole sample and for each gender, analysing the different pattern types (arches, loops, and whorls) of the entire impression and inside and outside the circle. The analysis of variance and the Kruskal–Wallis statistic test were used to analyse sexual dimorphism and the differences between the areas and types of patterns.

Table 1
Types of the minutiae or characteristic points used by the Spanish Scientific Police [21,22]

Types of minutiae	Definition
Ridge ending	A termination of a ridge
Bifurcation	When the minutiae form ridges to the right
Convergence	When the minutiae form ridges to the left
Fragment	Short ridge (length equal or less ten times its width)
Point o dot	One ridge unit, containing only one sweat gland pore
Break	Two ends of ridge very near and opposite
Enclosure	Where the ridge path divides and then comes together again
Overlap	Where two ridge ends meet and overlap on a bias
Crossbar	Ridge that separates from its direction crossing between two others
Bridge or crossover	Where a short ridge crosses from one ridge to join the next
Opposited bifurcations	Two ridges that join at one point
Y o M	When two bifurcations develop next to each other on the same ridge a unique formation
Dock	Crest end that enters between two other end ridges
Return	The turning around of a ridge without being part of the nucleus

3. Results

The classification and definitions used to analyse the variety of minutiae in the fingerprints appear in Tables 1 and 2. The relative frequency with which the different minutiae were found in the index or second finger (FII) appears in Tables 3 and 4. The most frequent minutiae were ridge endings, followed by convergences and bifurcations, the other minutiae showed considerably lower frequencies; dependence was found on sex in the sense of a major frequency of ridge ending, convergences, bifurcations, and enclosures in woman. Within the variety of bifurcations and convergences analysed, the simple forms (those that are neither followed nor preceded by breaks in any of the ridges of which they are formed) appeared

Table 2
The varieties of the minutiae or characteristic points used by the Spanish Scientific Police [21,22]

Bifurcation

BS. Simple bifurcation (the ridges show no interruptions)

BTUS. Bifurcation with tendency to unite on the superior or external branch whose length is five or more than five the width of the ridge

BTUI. Bifurcation with tendency to unite on the inferior or internal branch whose length is five or more times the width of the ridge

BTBS. Bifurcation with tendency to bifurcate on the superior or external branch whose length is less than five times the width of the ridge

BTBI. Bifurcation with tendency to bifurcate on the inferior or internal branch whose length in less than five times the width of the ridge

Convergence

CS. Simple convergence (the ridges show no interruptions)

CTUS. Convergence with tendency to unite on the superior or external branch whose length is five or more times the width of the ridge

CTUI. Convergence with tendency to unite on the inferior or internal branch whose length is five or more times the width of the ridge

CTCS. Convergence with tendency to converge on the superior or external branch whose length is less than five times the width of the ridge

CTCI. Convergence with tendency to converge on the inferior or internal branch whose length is less than five times the width of the ridge

Enclosure

OB. Big enclosure whose length is five or more times the width of the ridge

OS. Small enclosure whose length is less than five times the width of the ridge

Fragment

FB. Big fragments whose length is five or more times the width of the ridge

FS. Small fragments whose length is less than five times the width of the ridge

Break[a]

IS. Simple interruption: interruption on a crest without modification of the ridges

IE. Interruption with narrowing: interruption on a ridge with narrowing of the adjacent ridges

Opposite bifurcations[a]

STI. Secant type I: two ridges touch at one point

STII. Secant type II: Two ridges touch twice leaving a loop in the middle

[a] Varieties introduced by us.

Fig. 1. Fingerprint of index finger of the right hand. The count of the minutiae was made of the entire print area, and inside and outside of a circle designed according to the method described by Okajima [18].

more frequently. No dependence on gender was found for any of the subgroups.

The most frequent pattern type was the ulnar loop, followed by the whorl. Arches and radial loops were found much less frequently, Table 5. No significant association between gender and the type of general pattern was found.

The averages for minutia registered in all the samples and for each sex in the three areas being evaluated (the whole fingerprint and inside and outside the circle) appear in Table 6. The males presented a statistically significant greater number of minutiae in the three areas under evaluation than the females.

Ridge endings and convergences were the minutiae found in all the fingerprints studied, the other minutiae appeared in a

Table 3
Frequencies registered for minutiae (index finger, FII)

	FII		
	Total (%)	Males (%)	Females (%)
Ridge ending	53.16	52.37	54.06*
Convergence	15.32	15.12	15.56*
Bifurcation	12.91	12.76	13.09*
Fragment	5.30	5.37	5.22
Point o dot	3.11	3.35	2.83
Break	3.33	4.07	2.47
Enclosure	2.35	2.11	2.63*
Overlap	1.57	1.65	1.47
Crossbar	1.54	1.68	1.38
Bridge	0.91	0.91	0.90
Opposited bifurcation	0.29	0.35	0.23
Y or M	0.15	0.19	0.11
Dock	0.07	0.08	0.06
Return	0.00	0.00	0.00

* $p < 0.05$.

Table 4
Frequencies for the varieties of minutiae (index finger, FII)

	FII		
	Total (%)	Males (%)	Females (%)
Convergence	15.32	15.12	15.56
CS	13.70	13.44	14.00
CTUS	0.60	0.65	0.54
CTUI	0.58	0.61	0.54
CTCS	0.22	0.20	0.24
CTCI	0.22	0.22	0.22
Bifurcation	12.91	12.76	13.09
BS	11.27	11.07	11.50
BTUS	0.59	0.58	0.60
BTUI	0.56	0.62	0.49
BTBS	0.26	0.24	0.29
BTBI	0.23	0.24	0.21
Enclosure	2.23	2.10	2.63
OB	1.07	0.97	1.21
OS	1.26	1.13	1.42
Fragment	5.30	5.37	5.22
FB	2.18	2.30	2.03
FS	3.12	3.07	3.19
Break	3.32	4.07	2.47
IS	2.53	3.13	1.85
IE	0.79	0.94	0.62
Opposite bifurcations	0.29	0.35	0.23
STI	0.16	0.20	0.12
STII	0.13	0.15	0.11

variable number of individuals in the sample. The average number of times the different types of minutia appear amongst those individuals that had them, in the entire sample and for each sex appear in Table 7. The differences between the sexes were significant for ridge endings, bifurcations, breaks, and crossbars, which were on average found less often in the females.

The distribution and comparison of the number of minutiae in relation to the general pattern can be seen in Fig. 2. Their distribution within the arches, loops and whorls differs significantly for each characteristic in all areas under evaluation. The whorls contained a greater number of minutiae than the loops and arches, both in the entire impression and outside the circle. However, inside the circle the distribution found differed in so far as arches followed by loops and whorls contained a significantly greater number of minutiae.

Table 5
Frequency for the type of pattern on the index finger (FII)

General Pattern	FII			
	Total ($n = 200$)		Males ($n = 100$) (%)	Females ($n = 100$) (%)
	n	%		
Arch	12	6	7	5
Radial Loop	29	14.5	15	14
Ulnar Loop	85	42.5	44	41
Whorl	74	37	34	40

Table 6
Descriptive statistics for the count of minutiae over whole fingerprint and inside and outside a circle (index finger, FII)

Area	FII (mean, S.D.)		
	Total ($n = 178$)	Males ($n = 89$)	Females ($n = 89$)
Total area	80.94, 16.58	86.43, 15.79	75.22, 15.54*
Inside circle	52.26, 10.93	53.94, 11.62	50.58, 10.06†
Outside circle	28.68, 18.25	32.49, 18.61	24.87, 17.11*

* $p < 0.001$.
† $p < 0.05$.

As far as gender is concerned, the number of minutiae in relation to the general fingerprint pattern (arches, loops and whorls) was, significantly greater for the males than for the females in whole fingerprint and outside the circle, with the exception of the arches in the count of the whole fingerprint. Inside the circle, the loops and whorls of the males contained a greater number of minutiae. For the females on the other hand the same proved true for the arches, although as we mentioned previously, in neither case were these differences between the sexes significant (Fig. 2).

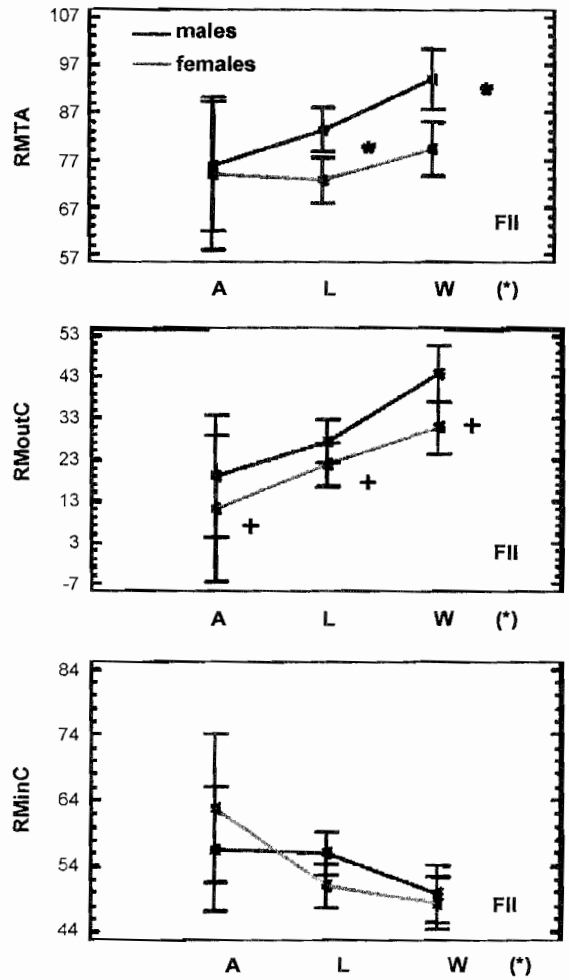

Fig. 2. Analysis and distribution of the minutiae (ANOVA). Recount of total area of the fingerprint (RMTA). Recount out side of circle (RMoutC). Recount inside of circle (RMinC). Arches (A), loops (L) and whorls (W). *$p < 0.001$; †$p < 0.05$.

Table 7
Descriptive statistics for the different types of minutiae (index finger, FII)

	Total			Males			Females		
	n	Mean	S.D.	*n*	Mean	S.D.	*n*	Mean	S.D.
Ridge ending	200	43.00	11.58	100	45.28	12.00	100	40.72	10.72
Convergence	200	12.37	5.46	100	13.03	5.75	100	11.71	5.08
Bifurcation	199	10.44	4.72	100	10.99	4.77	99	9.90	4.63
Fragment	189	4.52	2.92	94	4.94	3.10	95	4.11	2.67
Point o dot	145	3.47	2.89	78	3.72	3.37	67	3.18	2.18
Break	161	3.34	2.19	91	3.87	1.40	70	2.66	1.58
Enclosure	153	2.48	1.49	76	2.39	1.39	77	2.56	1.57
Overlap	136	1.87	1.06	78	1.83	0.89	58	1.91	1.26
Crossbar	136	1.83	1.04	72	2.01	1.07	64	1.62	0.98
Bridge	97	1.52	0.87	48	1.64	0.99	49	1.39	0.70
Opposited bifurcations	39	1.23	0.54	25	1.20	0.50	14	1.28	0.61
Y or M	21	1.14	0.48	14	1.14	0.53	7	1.14	0.38
Dock	12	1.00	0.00	7	1.00	0.00	5	1.00	0.00
Return	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00

† $p < 0.05$.

Table 8
Descriptive statistics for minutiae that showed statistically significant ($p < 0.05$) differences with respect to the type of design

	Arch			Loop			Whorl			
	N	Mean	S.D.	*N*	Mean	S.D.	*N*	Mean	S.D.	
Total convergence	12	8.17	4.67	113	9.78	4.26	74	11.84	5.09	10.17*
Fragment	11	4.18	2.18	107	4.24	3.10	71	5.00	2.70	6.07*
Males										
Ridge ending	7	35.00	10.01	59	43.69	9.91	34	50.00	13.94	9.24*
Females										
Convergence	5	5.80	2.17	54	9.24	4.06	40	11.30	5.12	8.55*
Fragment	5	3.80	1.48	53	3.53	2.45	37	5.00	2.92	7.68*

The relation between the type of pattern and the types of minutia are shown in Table 8. When the whole sample was analysed, this relation was only found to be statistically significant for the convergences and the fragments. The convergences were more numerous in the whorls, followed by loops and arches, the fragments were also more numerous in the whorls. When the samples of the different sexes were analysed, statistically significant differences for the ridge endings were found in the males, being more numerous in the whorls and less so in the arches. The same was found for the convergences and fragments in the females, in this case the convergences were also significantly more numerous in the whorls, followed by the loops which were on average lower in the arches, whilst the fragments, which although also more numerous in the whorls, appeared on average more often in the arches and less often in the loops.

4. Discussion

In the study of Human Biology, dermatoglyphics has traditionally been used to characterise the different populations, due to their unchanging genetic base and differences between populations. However, one of their features, the minutiae or characteristic points have not been studied extensively, despite the recommendations of certain authors for their interest to the study of genetics and the development of dermal ridges and their application in the identification process [11,12,24].

There is a need to study and analyse the scientific bases that determine the process of individualisation in personal identification, and any attempt to establish said bases must be based on the analysis of the variability of the minutiae, given that they are one of the pillars of dactyloscopic identification, whether it is used quantitatively (numerical standard) or qualitatively. [8,25]. A relevant aspect that would improve the identification process and should be taken into account is the knowledge of the frequency with which the different types of minutiae appear in the different human populations, as well as the topographic, digital and gender variations that may be present, as we have in fact seen in the study we have presented. All these aspects can be used to amplify and/or complete the information given in the investigative reports of the identification services.

As mentioned earlier, another problem with this type of study is the diversity of classifications [2,8,10,12–22]. The most recent classifications of Ashbaugh [8] and Champod [22] with nine main types, are the ones that resemble the most the ones used by the Spanish Police Scientists [21]. It would be of great interest if the criteria for classification within the scientific

Table 9
Frequencies of minutiae in different studies

	Gupta [30], 1000 PU	Osterburg [31], 39 (F)	Lin [27], 76 (F)	Santamaría [20], 1000 (F)	Kingston [15], 100PU	Steffen [16], 809 (P, W, A)	Sclove [28], 39 (F)	Stoney [10], 412*	Okajima [19], 1.590 (PU, W) R.H., FII	Champod [22], 172 W, 804 PU			Sarkar [32], 4030 (P, W)	Present work, 100 (PU, W, A)
										D. Z.	Out D.Z.	Periph	R.H., FII	R.H., FII
Minutiae	–	2.536	14.280	–	2.464	17.082	2.511	2.645	4.055	33.809	24.550	26.957	2.786	16.179
Ridge ending	7.5	8.32	9.6	53.4	45.9		49.70	56.8	74.8	42.0	57.1	65.8	64.58	52.37
Bifurcation	8.0	3.82	2.6	15.1	34.1	34.4	15.90	43.2	19.3	19.3	36.0	26.0	18.45	12.76
Convergence				13.1										15.12
Deviation	0.9			2.2		8.4								1.65
Bridge	0.8	1.22		1.3	1.9	4.6	5.58			9.2	4.1	2.1	0.00	0.91
Fragment	2.5	1.77	0.99	5.4			10.30		1.9				4.91	5.37
Break	0.9	1.39	1.2	1.6		0.2							2.44	4.07
Hook	2.0	0.75	0.48			9.5	3.50			12.8	6.8	5.2		
Enclosure	2.5	0.64	0.17	4.2	3.2	8.2	2.63			5.9	6.3	2.2	2.30	2.11
Point or dot	3.5	1.51	0.52	2.2	8.3		10.20	5.3	4.0				3.55	3.35
Double ridge						18.2				16.3	21.5	20.4		
Opp. bifurcation	0.5			0.2		0.4				1.2	3.7	1.1		0.35
Crossbar	0.5			1.3		3.4								1.68
Return	0.8			0.024										0.00
Minutie						1.9								
Divarcation		0.14	0.27			4.7	0.64			11.2	8.6	1.1		
Trifurcation		0.09				0.9	0.28							
Y or M						0.4								0.19
Dot														0.08
Bifurcation opposite end										6.6	6.2	0.9		
Ridges secondaries													3.77	
Auricular line			0.17		1.7									
Delta		0.20			3.1	0.8	1.35							
Multiple Occurrence		3.55												
Absence		76.60	0.839											

All the dates are reported to fingerprint of males. F: fingerprint. RH: right hand; PU: lunar loop, W: whorl, A: arch *Recount over distal area of the thumb. D.Z.: delta zone. Out D.Z.: out delta zone. Periph: periphery.

community and criminal laboratories were standardised, making it possible to progress in the study and comparison of these dactyloscopic features of the different human populations.

The designing of a circle associated with a specific number of ridges rather than one of a standard size, allows us to compare the number of minutiae between the sexes and between the principal fingerprint patterns. Removing the difference in the size of the finger and that of the dermal ridges (smaller in women than in men) [26]; our results reflect a heterogeneous distribution of the minutiae over the fingerprint area and differences in their density in accordance with the general pattern presented and the gender of the subject. Although we cannot directly compare these results with other studies, due to the different methods used, other authors such as Kingston [15], Lin [27] and Sclove [28] have already pointed

out that the density of the minutiae vary in accordance with their location on the fingerprint and more recently Champod [22] and Champod and Margot [29], have confirmed these results, finding a greater density of minutiae in the nucleus and in the delta than in the periphery of the impression.

The association between the number of minutiae and the principal pattern type found in our study had already been observed by other authors such Okajima [19] and Dankmeijer et al. [24]. Like Dankmeijer [24] in his study of Danish males, we find a greater number of minutiae in the whorls, followed by the loops and arches over the whole fingerprint. However, we find differences between populations with respect to the results obtained by Okajima [19] in the index finger of the Japanese population for the same area (the inside of an 18 ridge radius circle), finding a greater number of minutiae in the arches and loops than in the whorls. In our study, a different distribution in the density of the minutiae can be seen between the arches, loops and whorls, with a greater concentration in the arches and loops in the centre region and a more similarity distribution in the whorls between the inside and outside the circle (Fig. 2). On the other hand, the differences between the sexes in this respect, as much in the arches as in the loops and whorls, are significant in the periphery, this could be due to few ridges outside the circle for female subjects, but not inside the circle, showing that the gender differences found, as much in the area outside the circle as inside it (Table 6), are not only due to the size of the finger and the different number of dermal ridges that exist between males and females, and that the type de general pattern is not the one responsible for the gender differences at the interior of the circle but that there must be other factors that determine the significant differences between the sexes with respect to the total number of minutiae found, this being one of the most relevant results of our study.

This fact has not been made clear previously and reflects the need to take gender into account as a distinguishing characteristic of the features being analysed.

As far as the frequency of minutiae are concerned, it is difficult to compare our results with the limited number of studies that have tackled the evaluation of these dermatoglyphic characteristics, due to the disparity between the different criteria used, not only in the classification of minutiae, but in the method employed and the areas considered in the count. Table 9 shows the relative frequencies of the minutiae referred to in the different studies and populations. All of them are of male fingerprints, the section of the populations that have been studied of which practically all the studies of this type have been made. There are important differences in the methods used to estimate said frequencies [2,10,15,16,19,20,27,28,30–32]. The samples also vary greatly, as much in which ones are selected as their size. The arches have been included in our work, which is new in this type of studies.

For all these reasons it is only possible to make a very general comparison, which shows that the most frequent type of minutia in all the studies are ridge endings followed by convergences and bifurcations, in the majority of the samples these two types of minutia are treated as one entity, appearing relatively less frequently are short ridges and ridge enclosures, all other minutiae appear considerably less frequently. The only study of this type carried out on the Spanish population is that by Santamaría [20], our sample shows higher frequencies of convergences, breaks and points or dots, and lower frequencies of the other types of minutiae. These differences could be due to the sample, since Santamaría estimated them on the ten fingers (one thousand prints corresponding to the ten fingers of a hundred individuals) whereas ours correspond to the index finger only. On the other hand we registered a considerably lower frequency of ridge endings than that reported by Okajima [19] in the Japanese population, and a higher frequency of bifurcations and convergences, breaks and points or dots. One of the more extensive and interesting studies of this topic is that carried out by Champod and Champod and Margot [22,29]. These authors analyse the density and frequencies of the various types of minutiae as well as their directions and their variability in loops and whorls but the areas chosen for the analysis do not coincide with ours, making a direct comparison impossible. Despite the differences, certain aspects can be compared and we find that our results coincide in the greater frequency of convergences equivalent to a negative orientation in this study with reference to the positive orientation or bifurcations, revealing the need to treat these minutiae as different entities and not as one as has been the case in many of the studies carried out to date.

The frequency of arches, loops and whorls found, coincides with those found in other populations [32,33–37], in that there are an elevated number of arches and radial loops in this finger.

5. Conclusions

There are very few studies of the variability of minutiae ir fingerprints. This could be attributed to the difficulty o classifying and counting them even from good quality fingerprints. Although their analysis is subject to a certair degree of subjectivity, the need to tackle a systematic study o the different human populations makes it necessary to clarify the classification and definition of the different types o minutiae. The differences between the sexes with regard to th number of minutiae are not determined, at least not exclusively by the differences in the size of the finger and the thickness o the ridges or by the principal pattern. Other factors appear to b implicated in the sexual dimorphism found for this character istic.

When tackling any calculation of probable identity, we fee it is necessary to take into account, and so know, the frequenc with which different types of minutiae occur within th different human populations, as well as their relation to gende finger, pattern type and the area of the finger. This would permi the use of more specific probability models in accordance wit the different known aspects in each identity test.

In the particular case of the Spanish Scientific Police, th frequencies obtained for the different characteristic point in thi study, could be used in their investigative reports to quantify th degree of "rareness" of the points used when fingerprints c this finger are evaluated.

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