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Determining relationship between fingerprint and gender using 10 finger attributes

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ABSTRACT

This study investigates the relationship among fingerprint and gender for all 10 fingerprints. 410 fingerprints taken from 19 females and 22 males aged between 18 and 25 years old were considered for this investigation. This is the first comprehensive study in literature that investigates 10 fingerprints for Turkish citizens. Ridge density, ridge thickness to valley thickness ratio and total ridge breadth values gained from our fingerprint database were used to determine gender. The results have shown that gender determination is successful for Turkish citizens with any of ten fingerprints. The average values for ridge density-ridge breadth-RTVTR are 13.09-36.56-0.46 for men and 14.43-37.44-0.47 for women, respectively. The gender difference of ridge density is determined as 1.34, which is the lowest value among the other studies in the literature.

Keywords: Fingerprint, ridge density, RTVTR, ridge breadth, gender determination

10 parmak öznitelikleri kullanılarak parmak izi ile cinsiyet arasındaki ilişkinin tespiti

ÖZ

Bu çalışma 10 parmak için parmak izi ve cinsiyet arasındaki ilişkiyi araştırmaktadır. Yaşları 18 ve 25 arasında olan 19 bayan ve 22 baydan alınan 410 parmak izi araştırma için değerlendirilmiştir. Bu çalışma Türk vatandaşlarının 10 parmak izini inceleyen literatürdeki ilk kapsamlı çalışmadır. Parmak izi veritabanımızdan elde edilen tepe yoğunluğu, tepe kalınlığının vadi kalınlığına oranı ve ortalama tepe genişliği değerleri cinsiyeti tespit etmek için kullanılmıştır. Sonuçlar, Türk vatandaşları için on parmaktan herhangi biri ile cinsiyet tespitinin başarılı olduğunu göstermektedir. Tepe kalınlığı-tepe genişliği-RTVTR için ortalama değerler baylar ve bayanlar için sırasıyla 13,09-36,56-0,46 ve 14,43-37,44-0,47'dir. Tepe yoğunluğunun cinsiyetler arasındaki farkı literatürdeki diğer çalışmalara göre en düşük değer olan 1,34 olarak tespit edilmiştir.

Anahtar Kelimeler: Parmak izi, tepe yoğunluğu, RTVTR, tepe genişliği, cinsiyet tespiti

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1. INTRODUCTION

Fingerprints have the patterns constituted by the ridges on the surface of fingers. Fingerprint is peculiar to each person and remains stable for a lifetime. It is also the most suitable and reliable method for personal identification and verification.

Fingerprints are reliable for identification because they do not change from birth to death. Fingerprints consist of features that make classification possible and that enable a person to be recognized easily. They can be used not only to recognize criminals but also to discriminate amnesiac people and unrecognized dead bodies. Ever-increasing fingerprint control has become indispensable in police investigations [2]. There is no currently accepted method for determining the age of a fingerprint [24].

Fingerprints have great importance in scientific, morphological, criminological, biological and anthropological studies [1-23]. They are used to properly identify any person or suspect who touches any surface in the crime scene or fingerprint reader with an enough feature of fingerprints. Fingerprints give some or more information about gender, origin, face sketch, age, etc. [18-23,26]. Ridge numbers and characteristics are generally worked on [9]. In a recent study, Sagiroglu and Ozkaya have reported a study that predicts a person's face sketch from only fingerprints [16].

In recent studies, gender predictions from fingerprints have more attention in the scientific and judicial fields [3]. The number of ridges on the right hand is more than the number of ridges on the left hand by 20% in most people [6]. Gender recognition from fingerprint has facilitated for police to investigate the criminals [2]. Gender classification using fingerprints is a significant step in the studies of identifying the gender of criminals for judicial anthropology, and of narrowing the suspect list down [4]. Since the individual identity recognition is of high importance in forensic investigations, gender prediction from fingerprints is suitable and reliable method to be used in [5].

This study is organized in five sections. Section 2 presents the studies which analyze the relationship between fingerprint and gender. Section 3 introduces materials and methods. Section 4 gives the obtained results from experiments and its comparison with the literature. Finally, the work is concluded in Section 5.

2. GENDER PREDICTION FROM FINGERPRINTS

In a study conducted with 193 Argentinian adults from Puna-Quabrada region (2500m above sea level) and 200 Argentinian adults from Ramal region (500m above sea level), ridge density was identified in three different parts (radial, ulnar, proximal) for 10 fingers of each individual, and significant differences were found among the three parts in the samples taken from both regions. The results showed that radial ridge density is higher than ulnar ridge density, and ulnar ridge density is higher than proximal ridge density. The study also reported that females had higher ridge density and, thus, they had thinner ridges in all fingers and all parts [9].

In another study having 99 male and 110 female Indians aged between 6-25 years from Mataco-Mataguayo population, it was found that ridge density decreases with age, and ridge density is higher in distal parts rather than proximal parts. It was also seen that females had higher ridge density than males in the sample group of those who are over 12 years old. In addition, both genders in Mataco-Mataguayo population have ridge density values similar to Spanish samples in radial parts; however, they have higher ridge density than all the populations analyzed within the method so far [8].

In a recent study, the aim of authors was to check whether there are differences between the ridge density of fingerprints depending on where the counting area is placed and how the fingerprints are obtained. For this aim, 50 females 50 males total 102 people was selected and each fingerprints of them are obtained. They used plain and rolled fingerprint methods. The ridge density of each fingerprint was assessed in five different areas of the dactylogram. Regardless of the method used and of the position of the counting area, thumbs and forefingers show a higher ridge density than middle, ring, and little fingers in both sexes, and females present a higher ridge density than males in all areas and fingers. In both males and females, ridge density values on the core region are higher than those on the outer region, irrespective of the technique of fingerprinting used (rolled or plain) [25].

Moreover, in a study having 194 individuals aged between 18-25 years from North Indian population, different ridge density values among genders in radial, ulnar and proximal parts were compared with t-test. The results have shown that females have considerably higher ridge density than males in these three parts. Furthermore, ridge density has been found to be notably higher in ulnar and radial parts [10].

Another study conducted with 200 medical students aged between 20-30 years in Indian Mauritian population, females tended to have higher ridge density in distal parts on all fingers. Maximum ridge density on all ten fingers of males (12,26~12) was found to be lower than the minimum ridge density for all fingers of females (12,71~13) [11].

Furthermore, in a study of 684 Thailanders using transparent-adhesive tape technique (a black pencil for fingerprints collection and a magnifying lens for fingerprint patterns analysis), percentages of fingerprint patterns on left thumb are found to be 3.07, 0.61, 36.5 and 59.82 in males; and 5.59, 0.0, 43.02 and 51.4 in females for arches, radial, ulnar and spiral loops. In addition, it was found that males, compared to females respectively, have quite different fingerprint patterns on their right thumbs. They were observed as 1.84, 0.31, 30.37 and 67.48 in males, and as 4.6, 0.92, 44.48 and 59.82 in females for arches, radial, ulnar and spiral loops respectively [12].

Another study having with 550 individuals (275 females, 275 males) aged among 18-65 years from North Indian population reported that females have more ridges than males. The study also supported the fact that people whose ridge density is less than 13 ridges/25 mm2 are most likely to be males, and people whose ridge density is more than 14 ridges/25 mm2 are females [13].

Another study also presented the results having Indian population with 100 females and 100 males. The results have shown that fingerprints are most likely to belong to males and females if ridge density is 12 ridges/25 mm2 or less, or it is more than 12 ridges/25 mm2, respectively [14].

In addition, according to the results of another study with 380 male and 372 female Egyptians aged among 20-30 years, compared to males, females have significantly narrower finger breadth (right hand: male > 9.54 ≥ female, left hand: male > 9.38 ≥ female), smaller quad (right hand: male ≥ 16.1 > female, left hand: male > 15.1 ≥ female), higher ridge number (right hand: female > 21.0 ≥ male, left hand: female > 21.2 ≥ male) and higher ridge density (right hand: female > 1.35 male, left hand: female > 1.5 male). It was finally observed that ridge density of left hand is the only accurate parameter to determine the gender. The best classification accuracy achieved was 82% by combining ridge number, quad and ridge density [15].

The last study in the literature was to have 200 Spanish (100 females, 100 males) aged among 20-30 years. Fingerprints belong to females that females have significantly higher ridge density in distal part (radial and ulnar); however, it is not the same in proximal part [7].

As a result of this, it can be clearly said that, gender predictions can be achieved accurately for many nationalities. In these studies, prediction is based on only one fingerprint. This article focuses on ten fingerprints to predict gender with ridge density, RTVTR and ridge breadth for the first time.

3. MATERIALS AND METHODS

The aim of this study is to analyze all ten fingerprints of an individual to achieve the differences and understand the big picture of fingerprints. In the analysis, the fingerprints taken from 41 Turkish citizens (19 females, 22 males) aged among 18-25 years were used. All data were collected according to the permission from Gazi University Ethical Commission. Totally 410 fingerprints were used in this analysis. Each fingerprint was presented to have a square cut of 5 mm x 5 mm cropped from the upper right by taking the fingerprint core point as a reference. Ridge density, total ridge breadth and RTVTR values on the cropped pictures were acquired and used in the analysis.

Before collecting the samples, all individuals were requested to wash and clean their hands. The fingerprints were then obtained with the help of a fingerprint reader. The fingerprint pictures - primarily taken as colored- were converted into black and white. While the fingerprint was being analyzed, an area of 5 mm x 5 mm from the upper left was worked on. 80 pixels were obtained from the diagonal in the square cut. Black pixels were indicated as ‘0’, and white pixels as ‘1’. All these procedures were applied sequently to all 10 fingers. Total ridge breadth, ridge density and RTVTR values on the square cut were collected,

recorded, reorganized and then used in the analysis. Total ridge breadth, ridge density and RTVTR parameters are extracted by using "0" and "1" values. Total ridge breadth is explained by the total count of "1" values in 80 pixels, ridge density is explained by the total count of "1" clusters in 80 pixels and RTVTR is explained by ratio of total count of "1" values to total count of "0" values in 80 pixels.

As it can be seen in Figure 1, fingers were numbered as F1, F2, F3, F4, F5, F6, F7, F8, F9, F10 successively starting from the left little finger to right little finger.

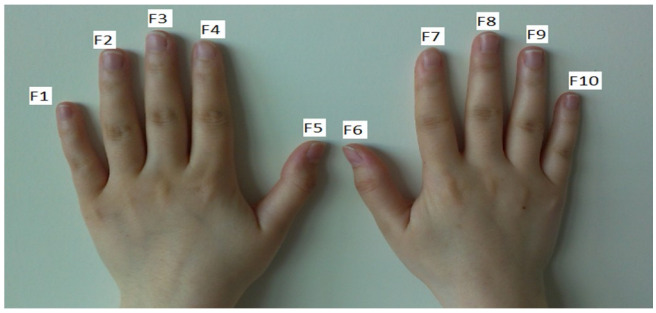

Figure 1. Numbering the fingers

4. RESULTS AND DISCUSSION

As stated earlier, the fingerprints acquired from ten fingers of two hands were used to analyze throughout this study. The results of all analyses are given in Tables 1-4 and Figures 1-3.

When we review the literature, it is generally recognized that ridge density values are higher in females compared to males. Likewise, total ridge breadth and RTVTR values are also higher in females.

The fingerprint ridge values of Turkish citizens were analyzed and given in Table 1. As can be seen in Table 1 (a), total ridge density mean in males is found to be lower than the mean of females, and this state does not change for right and left hands.

Total ridge breadth values are illustrated In Table 1 (b). When the values are evaluated, total ridge breadth mean in males is found to be lower than the mean of females, and this state does not change for right and left hands but the difference rate is very low in right hand.

The results of RTVTR rates are depicted In Table 1 (c). As it can be seen clearly in the table, statistical differences among males and females are very low in both hands according to RTVTR values. It is found that males have lower values than females in total RTVTR rates, and this state does not change for right and left hands.

In Table 2 (a), the statistics of ridge density means for all fingers of Turkish males and females are given. When the obtained ridge density values were analyzed, females have higher ridge density values. Minimum and maximum values are lower in males compared to females.

Statistics of total ridge breadth means for all fingers of males and females are summarized in Table 2 (b). As can be seen from the table, the total ridge breadth mean is lower in males; however, minimum and maximum values are quite close to each other.

In Table 2 (c), statistics of RTVTR rate means for all 10 fingers of males and females are given. RTVTR rate mean is a bit lower in males compared to females but minimum and maximum values are equal to each other.

The results for ridge density analysis for each finger of Turkish males and females are depicted In Table 3. Males have ridge density ranging from 8 to 17 (average 12.94) for left hand, from 9 to 18 (average 13.22) for right hand. Females have ridge density ranging from 8 to 18 (average 14.43) for left hand, from 7 to 20 (average 14.42) for right hand. Therefore, males have lower ridge density mean than females. In males, the finger that has the lowest mean value is 5th finger with the value of 12.09 and the finger that has the highest mean value is 8th finger with the value of 13.86. In females, the finger that has the lowest mean value is 6th finger with the value of 13.37 and the finger that has the highest mean value is 9th finger with the value of 15.21.

Figures 2 and 3 show the range of average ridge densities in right and left hands of females and males. When average ridge density values are analyzed, it can be seen that F5, F6 and F7 numbered fingers are similar to each other, and the values belonging to the remaining fingers are also similar to one another in females. The values are almost similar to the fingers F1, F4 and F6 in males. The values belonging to F2, F3, F9 and F10 fingers have also near values each other in males. The 8th finger is remarkably different from the others because it has the highest value of ridge density.

Table 1. The values for right and left fingerprints of Turkish citizens.

a) Total ridge density

Type of Analyses	Gender			
	Male		Female	
	Mean	Standard Deviation	Mean	Standard Deviation
Left hand fingers (1-5)	12.94	1.21	14.43	1.47
Right hand fingers (6-10)	13.22	1.10	14.42	1.41
Total ridge density	13.09	1.06	14.43	1.33

b) Total ridge breadth

Type of Analyses	Gender			
	Male		Female	
	Mean	Standard Deviation	Mean	Standard Deviation
Left hand fingers (1-5)	35.94	2.18	37.18	1.68
Right hand fingers (6-10)	37.18	1.62	37.69	1.53
Total ridge breadth	36.56	1.52	37.44	1.40

c) RTVTR rates

Type of Analyses	Gender			
	Male		Female	
	Mean	Standard Deviation	Mean	Standard Deviation
Left hand fingers (1-5)	0.45	0.03	0.46	0.02
Right hand fingers (6-10)	0.46	0.02	0.47	0.02
Total RTVTR rate	0.46	0.02	0.47	0.02

Table 2. The values for all ten fingerprints of Turkish citizens.

a) Analysis of ridge density means

Type of Analysis	Gender	
	Male	Female
Mean	13.09	14.43
Standard Deviation	1.06	1.33
Min	11.1	12.0
Max	14.9	16.5

b) Analysis of total ridge breadth means

Type of Analysis	Gender	
	Male	Female
Mean	36.56	37.44
Standard Deviation	1.52	1.40
Min	33.5	33.9
Max	39.3	39.4

c) Analysis of RTVTR rate means

Type of Analysis	Gender	
	Male	Female
Mean	0.46	0.47
Standard Deviation	0.02	0.02
Min	0.42	0.42
Max	0.49	0.49

Table 3. Ridge density values for 10 fingers of Turkish citizens

Finger No.	Gender					
	Male			Female		
	Mean	Standard Deviation	Range	Mean	Standard Deviation	Range
1	12.73	1.70	10-16	14.47	2.27	8-18
2	13.55	1.77	10-17	14.74	2.26	10-18
3	13.50	1.85	8-17	14.79	2.04	10-18
4	12.86	1.58	9-16	14.74	1.76	10-17
5	12.09	1.51	9-14	13.42	1.39	11-16
6	13.00	1.45	11-15	13.37	2.19	7-17
7	12.45	1.47	10-16	13.47	2.29	7-17
8	13.86	1.73	11-18	15.16	1.64	12-17
9	13.45	1.77	9-17	15.21	2.07	11-20
10	13.36	1.40	11-16	14.89	1.82	10-18
Average	13.09	1.62	8-18	14.43	1.97	7-20

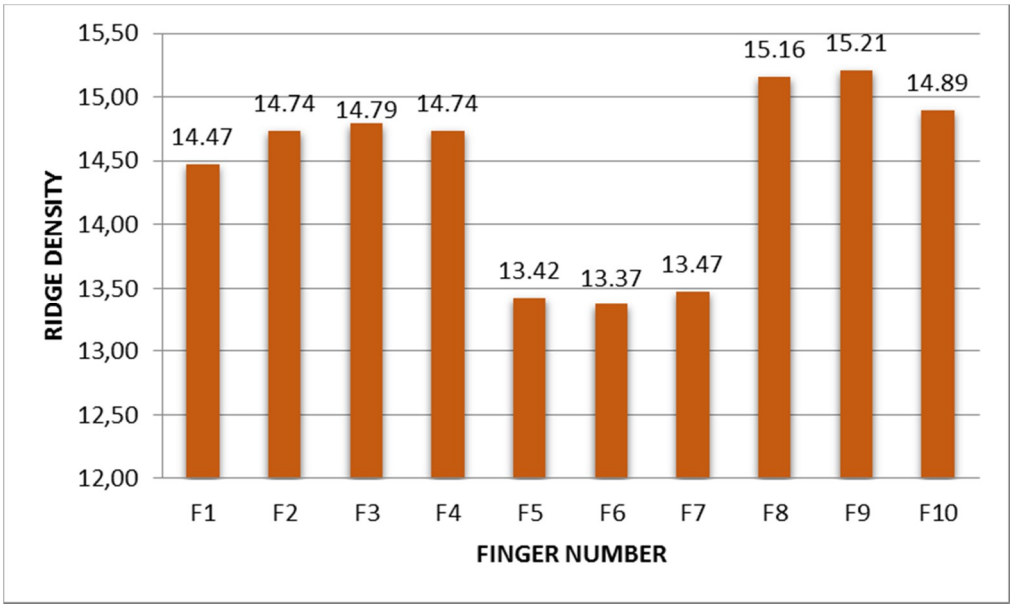

Figure 2. Average ridge density values for all fingers of females

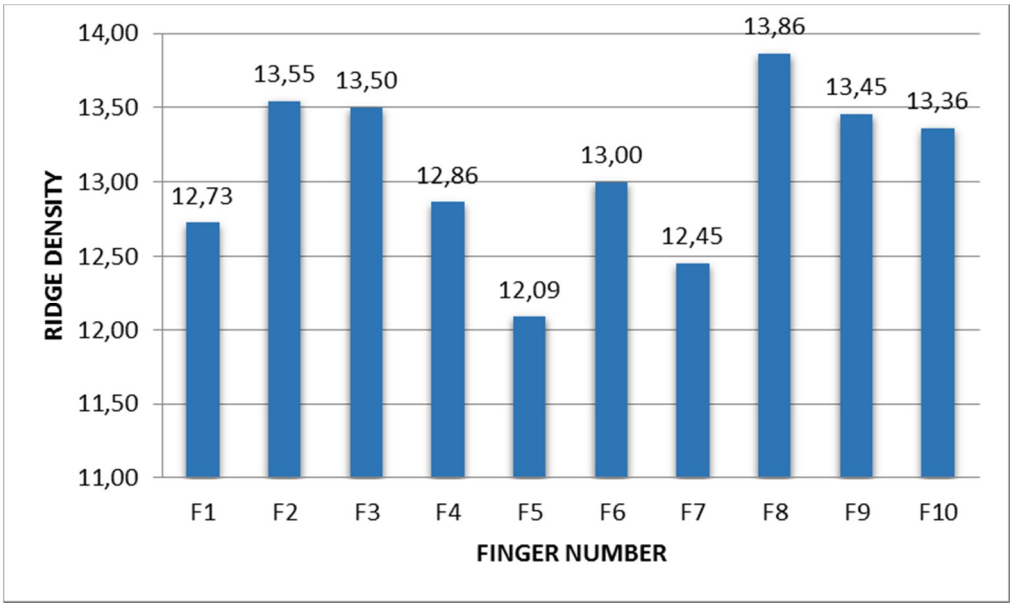

Figure 3. Average ridge density values for all fingers of males

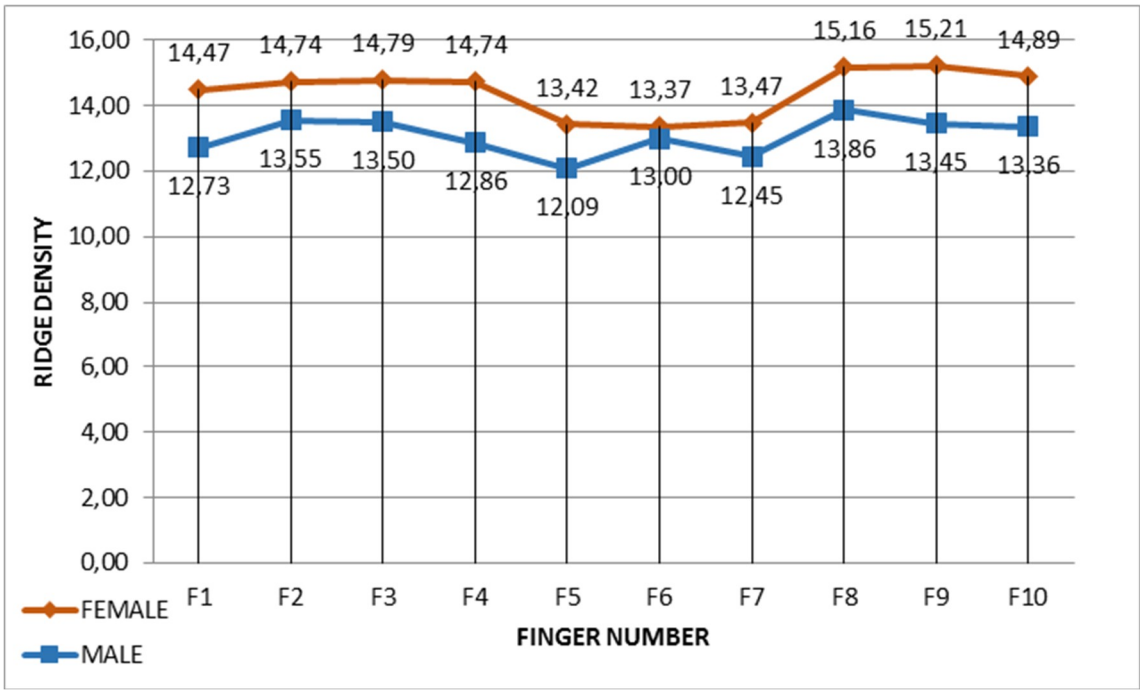

Figure 4. A different way of comparison of average ridge density for 10 fingers according to gender

Table 4. Ridge density differences in fingerprints of different populations according to gender.

Literature Comparison	Gender						Gender Difference
	Female			Male			
	Min.	Max.	Average	Min.	Max.	Average	
White American [17]	10.60	16.80	13.32	7.90	14.70	11.14	2.18
Black American [17]	9.70	16.00	12.61	8.2	14.30	10.90	1.71
Spanish [7]	14.60	21.50	17.91	13.00	19.22	16.23	1.68
Indian [14]	12.0	15.9	14.19	9.6	12.5	11.04	3.14
Chinese [2]	11.1	16.4	14.15	9.3	14.9	11.73	2.42
Malaysian [2]	11.4	15.3	13.63	9.4	14.4	11.44	2.19
Turkish (Present study)	9.6	17.6	14.43	9.8	16.2	13.09	1.34

As it can be seen in Figure 4, females have higher ridge density on their right and left fingers at a statistically significant rate not only one finger but also ten fingers as stated in the literature for one finger [23].

Descriptive statistics for fingerprint ridge density of all fingers are shown in Table 4. Average ridge density is found to be 13.09 in males and 14.43 in females. In Table 4, ridge density values obtained in this study are compared with the results of other studies. Turkish citizens show similarity to Chinese people especially in terms of minimum and maximum values. The difference between genders is found to be 1.34 in this study. It should be emphasized that the lowest gender difference belongs to Turkish in comparison with the references [2, 7, 14, 17].

5. CONCLUSIONS

This paper investigates to determine gender of a person for Turkish citizens using basic features of fingerprints. This is the first study to be conducted with Turkish citizens having 10-fingers. In order to achieve the task, ridge density, total ridge breadth and RTVTR values in the database were formed with fingerprints taken from 41 Turkish citizens (22 males, 19 females) in the analysis. Likewise the previous studies, the findings report once more that ridge density of females are more than the ridge density of males, and ridge density values in the left hands of females and males are quite different from each other (male = 13.09, female = 14.43). It was also found that ridge density values were quite close in the right hands of both genders. When 10 fingers were analyzed, it was found that males have the highest ridge density in their right middle finger, whereas females have the highest ridge density in their right ring finger (male = 13.86, female = 15.21). The average ridge breath is 36.56 and average RTVTR is 0.46 for men. The average ridge breath is 37.44 and the average RTVTR is 0.47 for women.

It was also found that, like ridge density, ridge breadth and RTVTR values were lower in males not only one finger but also ten fingers. This study proves that the gender of a fingerprint can be easily identified not only from one fingerprint but also all fingerprints.

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