DOI: https://doi.org/10.17816/fm737

Изменчивость плотности гребней отпечатков ладоней среди египтян в зависимости от распределения и дискриминации по признаку пола

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АННОТАЦИЯ

Обоснование. Определение пола как части биологического профиля жертвы или преступника играет важную роль в судебно-медицинских расследованиях и позволяет увеличить количество случаев успешного установления личности на 50%. Среди ранее опубликованных исследований гораздо больше тех, которые посвящены роли отпечатков пальцев в идентификации пола, тогда как отпечаткам ладоней до сих пор уделялось меньшее значение.

Цель исследования — оценить плотность гребней отпечатков ладоней и составить уравнение для установления пола с помощью гендерных параметров для конкретной популяции (египтян).

Материал и методы. Исследование проводилось с участием 200 условно здоровых молодых людей (113 мужчин и 87 женщин в возрасте 18–22 лет) родом из г. Каира (Египет). Отпечатки ладоней снимали красковым методом, после чего определяли плотность гребней на каждой из четырёх областей отпечатка.

Результаты. Женщины имеют более высокую плотность гребней, чем мужчины, во всех областях ладоней со значимо высокой статистической разницей (p <0,001) для всех областей обеих рук. Область с наиболее выраженной дискриминационной способностью на правой ладони — четвёртая (P4), на левой — первая (P1). При этом пол нам удалось определить с точностью до 70%. Кроме того, наблюдалась значительная корреляция показателей плотности гребней в каждой области ладони с другими её областями.

Заключение. Результаты исследования свидетельствуют о целесообразности использования отпечатков ладоней в качестве инструмента для определения пола в судебной медицине, что позволяет уменьшить количество сомнительных случаев на 50%.

Ключевые слова: египтяне; пол; отпечаток ладони; идентификация личности.

Как цитировать
Ramadan N., Ahmed A.M.S. Изменчивость плотности гребней отпечатков ладоней среди египтян в зависимости от распределения и дискриминации по признаку пола // *Судебная медицина.* 2022. Т. 8, № 3. С. 17–27. DOI: https://doi.org/10.17816/fm737

Рукопись получена: 14.07.2022 **Рукопись одобрена:** 04.10.2022 **Опубликована:** 24.10.2022

DOI: https://doi.org/10.17816/fm737

The variability of palm print ridge density among Egyptians regarding distribution and sex discrimination

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ABSTRACT

BACKGROUND: Sex determination, as a part of the biological profile of a victim or assailant, plays an important role in resolving different forensic cases as it reduces susceptibility to its half (fifty percent). Previous studies highlighted the role of palm print in sex identification, however, these studies were little when compared to fingerprints.

AIM: To estimate the density of palm print ridges and to make an equation for establishing gender using gender parameters for a specific population (Egyptians).

MATERIALS AND METHODS: The study was conducted on 200 healthy young adults (113 males and 87 males, aged 18–22 years) from Cairo city, Egypt. The palm prints were taken by inking method and four areas of the palm print were analyzed to count the ridge density of each palm print area.

RESULTS: Females describe higher ridge density than males in all palm areas with a significant high statistical difference (p <0.001) for all areas of both hands. The areas of highest sexual discriminatory power for the right palm was Palmar area 4 (P4) and for the left palm was Palmar area 1 (P1) and sex could be accurately identified at an accuracy of 70%. In addition, there was a significant correlation for ridge density in each palm area and other palm areas.

CONCLUSION: The current study raises hope for the usage of palm print a newly added tool for sex identification in the forensic field, thus decreasing suspicion by fifty percent.

Keywords: Egyptians; sex; palm print; identification.

To cite this article

Ramadan N, Ahmed AMS. The variability of palm print ridge density among Egyptians regarding distribution and sex discrimination. *Russian Journal of Forensic Medicine.* 2022;8(3):17–27. DOI: https://doi.org/10.17816/fm737

Received: 14.07.2022 **Accepted:** 04.10.2022 **Published:** 24.10.2022

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DOI: https://doi.org/10.17816/fm737

根据分布和性别歧视，埃及人掌纹脊密度的变化

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简评

论证。作为受害者或犯罪者生物特征的一部分，性别鉴定在法医调查中起着重要的作用，并可以使成功查明身份的数量增加50%。在之前发表的研究中，更多关注指纹在性别鉴定中的作用，而手掌印至今为止受到的关注较少。

该研究的目的是估计手掌印脊的密度，并使用特定人群（埃及人）的性别参数制定一个鉴定性别的方程式。

材料与方法。该研究涉及来自埃及开罗市的200名相当健康的年轻人（113名男性和87名女性，年龄在18-22岁）。手掌印是通过颜料方法而取得的，然后确定手掌印每四个区域掌纹脊的密度。

结果。女性手掌所有区域的脊密度均高于男性，双手所有区域的统计差异较高（p＜0.001）。右手掌辨别能力最明显的区域为第四（P4），左侧为第一（P1）。同时，我们能够确定性别，准确率为70%。同时，我们能够以高达70%的准确率确定性别。

结论。研究结果表明，在法医学中使用手掌印作为确定性别的工具是可行的，可以将可疑病例的数量减少50%。

关键词：埃及人；性别；掌纹；个人识别。

To cite this article
Ramadan N, Ahmed AMS. 根据分布和性别歧视，埃及人掌纹脊密度的变化. *Russian Journal of Forensic Medicine.* 2022;8(3):17–27.
DOI: https://doi.org/10.17816/fm737

收到：14.07.2022 **接受：**04.10.2022 **发布日期：**24.10.2022

INTRODUCTION

Dermatoglyphic patterns are the epidermal ridges which are naturally occurring in certain body adanareas or parts as palm, sole, finger…ect [1]. The study of these patterns are important as they are genetically determined and formed early intrauterine and mostly persist through life [2]. Many studies showed that dermatoglyphics has a great role in establishing ethnic differences [3].

Fingerprints had gain popularity in identification over the past years, however the published work regarding foot and palm prints and their role in identification are still not enough[1].

Sex determination, as a part of biological profile of a victim or assailant, plays an important role in resolving different forensic cases as it reduces suitability to its half (fifty percent)[4].

As they are constant for life, appear intrauterine and unique for individuals, fingerprints and palm prints are ideal tools in the field of identification and crime scene investigations[5][6][7]. Similar to fingerprint identification, palmprint identification is based on the basis of comparison between a known print (fingerprint) and a print of unknown origin (fingermark) [8].

In the literature, many studies showed sexual differences in ridge densities between males and females when using ridge density count method, nevertheless, the most of these studies were related to fingerprint ridge density[9–15].

For palm print ridge density, previous studies proved its usefulness in sex identification[1,14,16,17], and it was noticed that there was an ethnic difference when comparing palm print of different populations[7].

Krishan *et al*., (2014)[18] reached that palm ridge density is a better trait for biological variability within individuals and among populations than other polymorphic traits such as eye color and blood type, and it may be a useful preliminary means of distinguishing male and female identity in cases of mass disasters and identification of dismembered human forelimb parts[7]. In a most recent studies [8,19], the average density of minutiae in a Spanish sample revealed statistically significant topological and sexual differences [8] while, for the Croatian population [19], the measurements of the interdigital palmar area has been proven be capable of sex estimation from palmprints.

Rather than ridge density, significant gender differences in the frequency distribution of palmer creases were also noticed among Nigerian ethnic groups[3], while sexual difference in palmprint patterns was observed in Thai population [20].

Latent palm prints are frequently recovered from crime scenes, about 30% of the total recovered prints [21], furthermore, latent palm prints revealed greater ridge density for females than males [22].

In addition, the paucity of studies conducted to evaluate the sexual differentiating potentiality of palm print in Africa[1] and Arab countries especially Egypt, made the testing of palm print as sex identifier for Egyptians is very important. Therefore, the current study aims to evaluate the palm print ridge density as a tool for sex determination and to determine population-specific sex predictor equation for Egyptians using the palm print ridge density.

MATERIALS AND METHODS

Study sample: the study was conducted on 200 healthy adults (113 males and 87 females) in Cairo, Egypt. The age of the participants was between 18 and 22 years and the age window was narrow as Epidermal breadth varies with age. The participants were living in central Cairo so belonging to the Nile valley and delta ethnic group which make the majority of Egyptian population.

The study objectives, method, and steps were clearly illustrated and explained to the participants then written consent was taken from them before conducting the study.

Exclusion criteria: the subject will be excluded if he had any hand disease, fracture, injury, deformity, amputation, or any previous surgical procedures of the hand.

Data collection

To collect palm prints from the participant subjects; simple inking method was used as illustrated by cummins[23]. First, subjects were asked to effectively clean and dry their hands. Then an inking pad was used to apply ink equally with on the palm of the participant subject. A drawing sheet placed on a smooth table was used to apply impressions of both hands on it. The impressions was applied with high care to gain an obvious, complete and detailed prints of a whole palm without any overlapping. The demographic data of the participants; name, age, and sex, was recorded on a data sheet and assigned a number which was added to the palm print sheet.

The palm prints were analysed following the method used by Acree and krishan etal. [11,18]; four areas were selected to count ridge density, using a square about 5 mm × 5 mm drawn on a transparent film and placed on each area of four areas to be analysed (Fig. 1). A magnifying glass was used to count the epidermal ridges diagonally. The result count number represents the number of ridges in a 25 mm square area or the ridge density value. The ridge density was obtained individually from the designated areas on the palm prints.

The four measured palm print areas are:

First Palmar area (P1) — The transparent square was placed on the thenar eminence central prominent part.

Second Palmar area (P2) — The transparent square was placed on the hypothenar region distal to the axial triradius.

Third Palmar area (P3) — The transparent square was placed proximal to the second digit triradius.

DOI: https://doi.org/10.17816/fm737

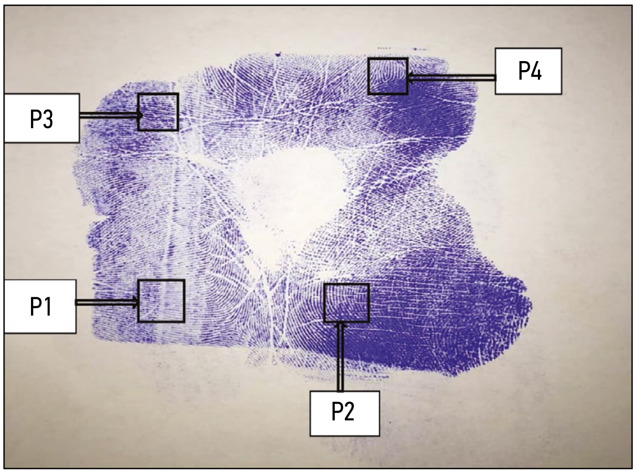

Fig. 1. Designated areas on the palmprint that were analysed for the palmprint ridge density

Fourth Palmar area (P4) — The transparent square was placed proximal to the fifth digit triradius[1,18].

Data analysis

Analysis of data was done by IBM computer using SPSS (statistical program for social science version 21) as follows:

- **Description** of quantitative variables as mean, SD, median, and IQR
- **Description** of qualitative variables as number and percent
- **Mann Whitney test** was used instead of independent t-test used to compare quantitative variables in non-parametric data (SD > 30 % mean). P ⩽0.05 means significant and P<0.01 means highly significant

The receiver operating characteristic (ROC) curve was done using the **med-calc program** to find the sexual discriminant ability and the best cut-off for different palm areas. Hosmer and Lemeshow (2000)[24] suggest that areas under the ROC curve is acceptable when measured between 0.70 to 0.80 and it is considered excellent when , measured between 0.80 to 0.90 and it is considered outstanding when equal 0.9 or above. However, when the area under the ROC curve equals 0.50 or below, this means that no discrimination between the outcome groups.

Multiple stepwise regression used to find significant predictors for the outcome

RESULTS

In this study, females describe higher ridge density than males in all four designated palm areas with a significant high statistical difference (p<0.001) for both hands (Table 1). The maximum ridge density was seen in P1 area of the right hand in both males (9.6±1.7) and females (9.9±1.6) while for the left hand, maximum ridge density was seen in P3 area in both males (9.1±1.6) and females (9.9±1.6). The area of highest sexual discriminatory power in the right palm was P4 (Z-value = 5.229), while sexual dimorphism in the left palm was highest in P1 area (Z-value = 5.438) and total left-hand ridge density (Z-value = 5.409).

In addition, when comparing ridge density in each area with other areas of both hands; a highly significant correlation was detected between them (p<0.001), and many of these correlations were acceptable with the highest correlation (r= 0.787) was between the average density of right hand when compared with area four of the right hand (P4) and the left hand average (Table 2).

The cut of point of each area ridge density was detected using the ROC curve (Table 3); The best area in the right hand that could be used for sex identification is P4 while in the left hand the most potential area for sex

Table 1. The difference between females and males in ridge density of all areas of both hands

		males			females			Z-value	*p*. value*
	Area	N	Median	Mean±SD	N	Median	Mean± SD		
Right hand	P1	113	9(8:10)	9.6±1.7	87	10(9:11)	9.9±1.6	4.691	<0.001
	P2	113	9(8:10)	9.1±1.5	87	10(9:11)	9.8±1.6	3.839	<0.001
	P3	113	9(8:10)	8.8±1.7	87	9(9:11)	9.7±1.5	4.817	<0.001
	P4	113	8(7:10)	8.5±1.7	87	9(9:10)	9.5±1.5	5.229	<0.001
	Total hand	113	8.5(7.75:9.5)	8.93±2.28	87	9.5(8.75:10.38)	9.48±1.38	4.838	<0.001
Left hand	P1	113	9(8:10)	8.8±1.6	87	10(9:11)	9.8±1.6	5.438	<0.001
	P2	113	9(8:10)	9±1.4	87	10(9:11)	9.9±1.6	5.028	<0.001
	P3	113	9(8:10)	9.1±1.6	87	10(9:11)	9.9±1.6	4.316	<0.001
	P4	113	8(7:9)	8.5±1.5	87	9(8:10)	9.3±1.6	4.465	<0.001
	Total hand	113	8.75(8:9.5)	8.76±1.27	87	9.5(8.63:10.5)	9.54±1.62	5.409	<0.001

Note. *p <0.01 — highly significant, *p* ⩽0.05 — significant.

DOI: https://doi.org/10.17816/fm737

Table 2. Pearson's correlation between ridge density of the four studied areas of both hands

			Right hand					Left hand				
			P1	**P2**	**P3**	**P4**	**Average**	**P1**	**P2**	**P3**	**P4**	**Average**
Right hand	P1	r	1	.474**	.523**	.591**	.744**	.594**	.525**	.525**	.458**	.624**
		p value	.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	P2	r	.474**	1	.492**	.495**	.688**	.521**	.609**	.544**	.380**	.642**
		p value	<0.001	.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	P3	r	.523**	.492**	1	.551**	.716**	.508**	.507**	.571**	.520**	.628**
		p value	<0.001	<0.001	.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	P4	r	.591**	.495**	.551**	1	.787**	.506**	.512**	.531**	.584**	.668**
		p value	<0.001	<0.001	<0.001	.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Average	r	.744**	.688**	.716**	.787**	1	.613**	.610**	.617**	.559**	.787**
		p value	<0.001	<0.001	<0.001	<0.001	.	<0.001	<0.001	<0.001	<0.001	<0.001
Left hand	P1	r	.594**	.521**	.508**	.506**	.613**	1	.507**	.479**	.527**	.777**
		p value	<0.001	<0.001	<0.001	<0.001	<0.001	.	<0.001	<0.001	<0.001	<0.001
	P2	r	.525**	.609**	.507**	.512**	.610**	.507**	1	.557**	.394**	.738**
		p value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	.	<0.001	<0.001	<0.001
	P3	r	.525**	.544**	.571**	.531**	.617**	.479**	.557**	1	.440**	.752**
		p value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	.	<0.001	<0.001
	P4	r	.458**	.380**	.520**	.584**	.559**	.527**	.394**	.440**	1	.736**
		p value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	.	<0.001
	Average	r	.624**	.642**	.628**	.668**	.787**	.777**	.738**	.752**	.736**	1
		p value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	.

Note. *p <0.01 — highly significant, p ≤0.05 — significant.

Table 3. ROC curve for palm print ridge density

		*AUC	Z-value	95% CI	P value	Cut off point	Sensitivity	Specificity	+PV	-PV
Right hand	p1	0.652	4.691	0.594 to 0.708	<0.001	>8.25	79.41	44.9	57.1	70.2
	p2	0.627	3.839	0.568 to 0.684	0.001	>9	57.04	64.63	59.7	62.1
	P3	0.656	4.817	0.597 to 0.711	<0.001	>8.5	78.36	47.95	58	70.7
	P4	0.671	5.229	0.611 to 0.727	<0.001	>8.5	76.38	55.24	60.2	72.5
	Average	0.657	4.838	0.598 to 0.712	<0.001	>9	61.03	65.99	62.4	64.7
Left hand	p1	0.674	5.438	0.615 to 0.728	<0.001	>9	55.97	69.86	63	63.4
	p2	0.662	5.028	0.604 to 0.717	<0.001	>9	58.52	67.81	62.7	63.9
	p3	0.641	4.316	0.582 to 0.697	<0.001	>8.25	81.48	42.86	56.7	71.6
	P4	0.648	4.465	0.588 to 0.704	<0.001	>8.35	66.92	57.34	58.8	65.6
	Average	0.677	5.409	0.619 to 0.731	<0.001	>9.25	57.35	73.47	66.7	65.1

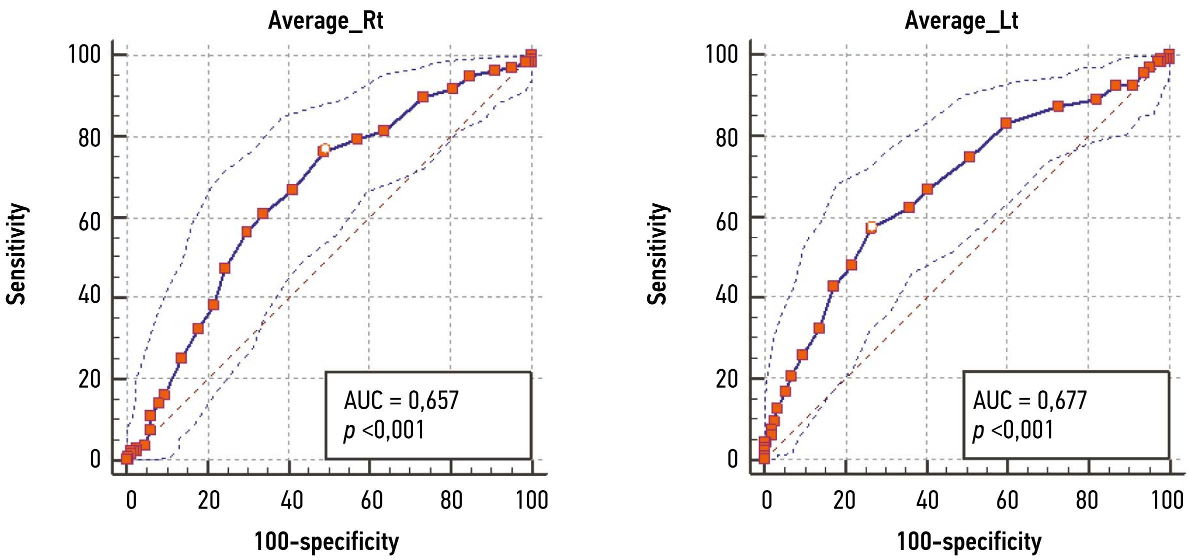

Fig. 2. ROC curve for average palm print ridge density of each hand, Rt — right hand, Lt — left hand. AUC — area under the curve, *p* <0.01 — significant differences.

determination is P1 and average ridge density of left palm print (fig. 2).

Stepwise multiple regression model was conducted to find the most significant predictors for gender, finding that best predictors for sex identification were P4 of right hand and P1 and average of left hand. Furthermore, gender could be detected using the following equation:

$$\text{Gender} = \frac{e^{1.319\ -0.287*P4Rt\ -0.259*P1Lt+0.419*Average\ Lt}}{1+e^{1.319\ -0.287*P4Rt\ -0.259*P1Lt+0.419*Average\ Lt}}$$

The cut off value of this model was 0.5. This means that when this model is applied practically, the resulting predicted values between 0.0 and <0.5 are classified as males, whereas values between 0.5 and 1.0 are classified as females.

In order to test the reliability of the present logistic regression model, we back tested the model against samples of the study population. The observed (actual) gender of the subjects was compared with the predicted gender obtained. It appears that males were correctly predicted 77% of subjects, while females were correctly predicted in 62.1% of subjects. Consequently, the present model could predict successfully the gender category of 70% of all studied subjects.

DISCUSSION

Recently, dermatoglyphics gained popularity in the field of forensic identification. Palm print ridge density and ridge breadth was investigated using different methodologies and among different populations.

In this study, ridge density in four palm print areas was tested for sex identification among Egyptians, females were significantly higher in ridge density of all palm areas than males. Many authors (table 4) were able to prove sexual dimorphism of palm print ridge density for different populations; two studies were conducted on Indians; Kanchan et al. (2013)[14] also reported significant sex differences for the palm print ridge density. They noticed that females have high ridge density than males in all the four studied areas except the right P3 area. Krishan et al.[18] also approved that Indian females have higher ridge density than males.

For Sudanese, Ali & Ahmed [1] were in accordance with this study; they approved significant sexual difference between females and males in ridge density for all palm areas. Similarly, *Moorthy & Rajathi 2020*[17] also approved sexual dimorphism of palm print ridge density among Malaysians.

Gutie´rrez-Redomero and Alonso-Rodrı´guez[16] also approved the sexual dimorphism of palm print ridge density, however they studied five palmprint areas (thenar/first interdigital (T-I), hypothenar (HT), second interdigital (II), third interdigital (III), and fourth interdigital (IV)) and used two methods of ridge density counting (Cummins et al. and the other by Acree), and they reached that the area that the best sex discriminant area was the thenar-I area for both hands, even when using either method. Recently, Rivaldería and Gutiérrez-redomero [8]also assessed the topological and sexual variability for the minutiae density in Spanish which matches the topological and sexual variability of ridge width or density.

In other studies, palm print was approved as a tool of sex determination from latent prints[22][25]. In addition, Badiye et al. [26] showed that males were found to have significantly higher in distances between the palmar tri-radii (deltas) than females in Indian sample, while for the Croatian population, Jerković et al, [19] were able to prove that the measurements of the interdigital palmar area were able to determine sex at accuracy of 81% to 87%.

The sexual dimorphism of the palmprint ridge density can be explained by many theories; the genetic background was explained by Jantz (1977)[27] who suggested that the sex

Table 4. Previous studies about the potentiality of palm print ridge density in sex identification

Study	Year	Population	Accuracy		Best area	
			Right hand	Left hand	Right hand	Left hand
Current	2021	Egyptians	70%		P4	
Rivaldería and Gutiérrez-redomero[8]	2021	Spanish			minutiae density*	
Jerković etal[19]	2021	Croatian	81% to 87%.		the interdigital palmar area*	
Ali & Ahmed[1]	2020	Sudanese	69%-78.8%	62.8%-77.8%	P4	P3
Moorthy & Rajathi[15]	2020	Malaysian				
Badiye et al.	2019	Indian			distances between the palmar tri-radii*	
Krishan et al[16]	2014	North Indian	58.9 %–66.8 %		58.8–71.7 %	P4
Gutie´rrez-Redomero and Alonso-Rodrı´guez[14]	2013	Caucasian Spanish			the thenar-I	
Kanchan et al.[12]	2013		70.2%-71.8%		P4	P4

Note. * The method used by the authors rather than the methodology of the current study.

chromosomes, particularly the Y chromosome, play a role in dermal ridge development (Kralik 2003)[28] then Krishan et al. (2010)[15] discussed the possibility of some associated genes of dermal ridges residing in the X chromosome. Furthermore, Environmental factors, such as poor nutrition and diseases, in the prenatal period can affect males more than females[29]. Another cause of sexual dimorphism of palmprint ridge density is that male hand and palm dimensions are larger than females[30].

Moreover, in the current study; there was highly significant correlation between ridge density in each palm area and other palm areas. This result was also accordance with Ali and Ahmed [1] who concluded a statistically significant correlation between the ridge densities of all the studied areas in both sides among both sexes. Also this correlation was approved by Krishan et al 2014 [18], however the correlation was not strong and not for all areas, and the maximum correlation was observed between ridge densities in the P3 and P4 areas in males on the left side, and among females bilaterally.

In the current study, the assessment of the potential of different areas to estimate sex using the ROC curve analysis showed that The areas of highest sexual discriminatory power were P4 in the right palm and P1 area in the left palm. Ali and Ahmed [1] also reached that the best areas to estimate sex were P4 on the right palm while for the left hand the best area was P3 not P1 as our study. In North Indian, Krishan et al [18] reached that the maximum sexing potential was found in P4 in both hands.

The current study showed that sex can be determined using palm print ridge density for Egyptians at an accuracy of 70%. This percentage was near to percentage reported for Sudanese [1] which was between 62.8 % and 77.8 % on the left palm and 69.0 % and 78.8 % on the right palm and was higher than those reported for North Indians (right palm, 58.9%–66.8 %, and left palm, 58.8–71.7 %) [18].

CONCLUSION

ridge density of four palm print areas was tested for sex identification among Egyptians, females were significantly higher in ridge density of all palm areas than males and The areas of highest sexual discriminatory power were P4 in right palm and P1 area in left palm. Furthermore, sex could be identified using palm print ridge density at an accuracy of 70 %, which raises hope for the usage of palm print a newly added tool for sex identification in the forensic field, thus decreasing suspicion by fifty percent.

ADDITIONAL INFORMATION

Funding source. This study was not supported by any external sources of funding.

Competing interests. The authors declare that they have no competing interests.

Authors' contribution. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work. Nazih Ramadan — the conception and the design of the work, supervision of data collection, interpretation of data, drafting the work and final approval of the version to be published; Asmaa Mohamed Sayed Ahmed — revision of the study design, samples collection, revision of the manuscript draft and final approval of the version to be published.

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