# IMPACT OF GENDER AND RACE ON FINGERPRINT RECOGNITION SYSTEM IN EGYPTIANS VERSUS MALAYSIANS

BY

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## ABSTRACT

*Finger prints have been shown to be genetically determined, conservative in their evolution, and different between and within population groups. Finger ridges and ridge patterns are highly heritable, durable, and age-independent human traits and have been studied as a model quantitative trait in humans for over 80 years.*

*This study was conducted to determine finger ridge count and pattern among Egyptians and Malaysian subjects in order to illicit the differences between them, as well as to determine sex impacts on both groups.*

*Four equal groups of 100 persons each were included from Egyptian and Malaysian people of both sexes. All were healthy and within age range of (18-21) years old. Bilateral digital prints from each one were obtained by inking procedure. Ridge count per 25mm$^2$ is determined together with assessment of ridge pattern type. Statistical analysis was done with references to both sexes in both groups.*

*Gender based variation in ridge count in both Egyptian and Malaysian subjects were detected, where males tend to have significantly lesser number of ridges compared to females. 50.5% of males were found to have a ridge count of 12. Beyond 12 ridges the number of males decreases rapidly and no male was found to have more than 15 ridges. On the other hand, no females were found to have 10 ridges. There was a highly statistical difference in ridge density between Egyptian and Malaysian females, and no statistical difference between Egyptian and Malaysian males. Ridge patterns show significant variation among both sexes in the included groups. Ulnar loops were significantly greater in females than in males while in males whorls were significantly greater. Ulnar loops were the predominant ridge pattern among the Egyptians, while whorls were more common among the Malaysians.*

**Key Words:** *Finger Prints, Ridge Count, Ridge Pattern, Gender, Egyptian, Malaysian.*

## INTRODUCTION

Fingerprints of an individual have been used as one of the vital parts of identification in both civil and criminal cases because of their unique properties of absolute identity (Nandy, 2001).

Since 700 AD, the science of fingerprints has been used for the purpose of identification. Chinese used fingerprints in official documents since 3000 BC (Rutty

et al., 2007). The system was first used in India in 1858 by Sir William Herschel to prevent impersonation, but the credit is given to Sir Francis Galton for having it systematized for the identification of criminals. His system was officially adopted in England in 1894, and was further modified by Sir Edward Henry. Afterwards the studies have been conducted on fingerprints mainly their types, classification, methods of lifting, recording and materials used to develop fingerprints (Subrahmanyam, 2001).

Through decades of scientific research, the hand has come to be recognized as a powerful tool in the diagnosis of psychological, medical and genetic conditions. It was in 1926 when Cummins introduced the term "Dermatoglyphics which refers to the study of the naturally occurring patterns of the surface of the hands and feet (Blanka and Milton, 1976).

Dermatoglyphic traits have been shown to be genetically determined and conservative in their evolution and different between and within population groups establishing and confirming the historical relationship between and within populations (Patrick, 2002).

Development of a fingerprint into the permanent, unique structure that we see on our fingertips is not a simple process; there are many components and anatomical changes that go into making it. Around 6-8 weeks after conception the volar pads (ball like structures that make up the contour of the fetal hand) form; by 10-12 weeks after conception the volar pads begin to recede; around the 13th week skin ridges appear and take the shape of the receding volar pad; lastly around the 21st week after conception the fingerprint patterns are complete (Wertheim and Maceo, 2002).

Holt (1968) reported that total finger ridge count (TFRC) is the most inheritable feature in dermatoglyphics. Ridge count is related to two different timed events; the timing of the onset of volar pad regression versus the timing of the onset of primary ridge formation.

There are three basic fingerprint patterns; arch, loop, and whorl. These patterns can be further classified into tented arches, plain arches, radial loops, ulnar loops, plain whorls, central pocket loop whorl, double loop whorl, and an accidental whorl. The pattern area is surrounded by two innermost ridges which start parallel and diverge; these are known as the type lines. During fingerprint development, the ridges form in three distinct locations on the end joint of the finger and converge; it is where these three ridge fields meet that form the delta (Wertheim and Maceo, 2002).

The study of palmar, and finger prints has a primary aim of identifying individuals' sex, race, ethnic differences as well as serving as a tool in the diagnosis of congenital malformations (Penrose, 1967, Holt, 1968 and Holt, 1975).

## *AIM OF THE WORK*

This study was conducted to determine finger ridge count and patterns among Egyptians and Malaysian subjects in order to clarify the differences between them, as well as to determine sex impacts on both groups.

## *SUBJECTS AND METHODS*

The study was conducted on 400 medical students from faculty of Medicine Cairo University (Egyptians & Malaysians). Equal groups of males and Females were allocated. All were healthy & within age range of 18-21 years. Egyptians were with Arabian parents and grandparents. Malaysians were with Asian Parents and grandparents. Informed consents were taken before participation in the task.

The digital prints were obtained by inking procedure according to Antonok (1975) using the following materials:

- An inking pad with black Printer's ink.
- Standard cards measuring 8x8 inches (20x20 cm) of average durability and its surface is slightly glazed.
- A magnifying hand lens.

**Steps of the procedure:**

- The skin of the hand was cleaned by alcohol and dried before printing,
- A plain print is made by contact of the ball of the finger without rotation of the digit. All ten finger prints are obtained from each individual.
- The print cards contain all ten inked digital print impressions of an individual.

Then ridge counting is done according to Mark (1999) method as follows: Epidermal ridges from each finger print were counted within 5x5mm square drawn in the upper center of the tip of the finger by counting the number of ridges transecting a line of 5mm length and the magnifier is oriented over the print so that, the line crossing the ridges at right angles and every ridge meets or transects the line is counted. Epidermal ridge counts were not analyzed within the central core regions due to the variability of pattern shapes and the potential problems of recurving ridges being counted more than once within these regions, while areas outside of the central core region do not have this confounding problem making them more suitable for ridge density determinations for this study. The ridge touched or crossed by the opposite extremity of the line is the last ridge included in the count.

Then the mean ridge count (MRC) was calculated for each subject.

Finally, the ridge pattern of each subject was determined and described as one of the basically identified ridge patterns (Arches, Whorls, Ulnar and Radial loops).

**Statistical data analysis:**

Data was statistically presented and analyzed using a computer supplied with SPSS program version 10. One way ANOVA test, t- test and Chi square test were used and the P value was considered significant when it was < 0.05 and highly significant when it was < 0.005 (Altman, 1991).


**Figure (1):** The mean ridge count (MRC).

## *RESULTS*

Table (1) & (2) show that the males tend to have lesser number of ridges compared to females. 50.5% of males were found to have a ridge count of 12/25 $mm^2$. Beyond 12 ridges/25 $mm^2$ the number of males decreases rapidly and no male was found to have more than 15 ridges/25 $mm^2$. On the other hand, no female was found to have 10 ridges/25 $mm^2$. The number of females with 15 ridges/25 $mm^2$ (57.5%) was very high as compared to males. The mean ridge count is 11.89 ridges /25$mm^2$ for males and 14.58 ridges/25$mm^2$ for females. There was a highly significant difference between males and females.

Table (3) & (4) show that there is no statistically significant difference in ridge count between Malaysians and Egyptian subjects. In both groups, the majority of the personnel have ridge count of 15 ridges/25$mm^2$ (28% & 33% respectively), while the least described count was 10 ridges/25$mm^2$ (2% & 3% respectively).

Table (5) Shows that fingerprint ridge count of 12 ridges/25 $mm^2$ or less is found to be more likely of males' origin in Egyptian subjects and a mean ridge count of 15 ridges/25 $mm^2$ is more likely of females' origin in Egyptian subjects. Fingerprint mean ridge count of 11 ridges/25 $mm^2$ is found to be more likely to be of males' origin in Malaysian subjects and a mean ridge count of more the 15 ridges/25 $mm^2$ is more likely of females' origin in Malaysian subjects.

There was no significant difference in ridge count between Malaysian and Egyptian males as shown in Table (6). Yet, there were highly significant differences between Malaysian and Egyptian females as shown in Table (7), Malaysian females & males as shown in Table (8) and Egyptian females & males as shown in Table (9).

Digital ridge patterns distribution in the whole studied sample was illustrated in tables (10, 11 & 12), where ulnar loops were the most predominant pattern (44.45%) followed by whorls (31.2%), arches (22.6%) and the least were the radial loops (1.75%). Ulnar loops were highly manifested in females (51.2%), while in the males whorls predominate (37.7%) as shown in Table (10). Also, ulnar loops were the predominant ridge pattern among the Egyptian subjects (62.2%), while whorls were more common among the Malaysian subjects (50.9%) as shown in Table (11). Table (12) shows sex impact on ridge pattern distribution among Malaysians and Egyptians. Whorls predominate in Malaysian males (67.8%) while in Malaysian females whorls and ulnar loops are equally manifested (34%). Ulnar loops were the commonest among Egyptian males as well as females (56% & 68.4% respectively).

## *DISCUSSION*

The science of fingerprints or dermatoglyphics had acclaimed and reputed as a basic tool for individualization, particularly in forensic investigations (Adebisi, 2009). Dermatoglyphics is a scientific method for anthropological, medico legal and genetic studies. Its genetic profile is used to study familial inheritance as well as to diagnose genetic diseases (Igbigbi and Msamati, 2005).

Many studies have been conducted on ridge count but, mainly for racial determination and genetic inheritance of ridge density. The present study has been conducted to broaden the horizon of ridge count so as to determine sex variation by finger print ridge count and pattern in Egyptian and Malaysian subjects.

In the current study, males tend to have significantly lesser number of ridges compared to females. 50.5% of males were found to have 12 ridges/25 $mm^2$. Beyond 12 ridges the number of males decreases rapidly and no males were found to have more than 15 ridges. On the other hand, no females were found to have 10 ridges, whereas 57.5% of females have 15 ridges.

These results coincide with the results published by Mark (1999) who stated that females have greater ridge density than males with difference of 2.18 ridges/25 $mm^2$ among Caucasian groups and 1.71 ridges/25$mm^2$ among African & American groups.

Acree (1999) explained the phenomenon as he found that fingerprints of females tend to have a thinner epidermal ridge detail compared to those of males. This would lead to a higher ridge density in females compared to males.

Bosco etal. (2001) believes that sex chromosomes influence the size of the cells by controlling its fluid content. The more sex chromosomes the higher the fluid content which would result in larger cells that would form larger pads, which would require more ridges to cover them. These larger volar pads may then affect the timing events set by Holt (1968) in which he believed played the dominant role in determining total finger ridge count. The larger the volar pad, perhaps the longer it would take for regression and thereby giving the primary ridge formation a longer time to form ridges, resulting in a higher ridge count.

The results of the present work showed that Egyptian females have significantly higher ridge count than Egyptian males, where fingerprint ridge number of 12 ridges/25 $mm^2$ or less is found to be more likely of males' origin in Egyptian subjects and a mean ridge count of more than 14 ridges/25 $mm^2$ is more likely of female origin in Egyptian subjects. The results show that Malaysian females have significantly higher ridge count than Malaysian males, where fingerprint mean ridge count of 11 ridges/25 $mm^2$ or less is found to be more likely of males' origin in Malaysian subjects and a mean ridge count of more the 13 ridges /25 $mm^2$ is more likely of females' origin in Malaysian subjects.

These disparities may be due to genetic as well as environmental factors as it has been reported that digital dermatoglyphic patterns are genetically determined and influenced by environmental, physical and topological factors (Nandy, 2001). This is in line with the work on the dermatoglyphic variations in five ethno – geographical cohort for Indian population. Highly significant variations were found for total ridge count between North versus East cohort and East versus West cohort (Sharma et al., 2008).

As regards frequency of the digital patterns and sex differentiation obtained from the studied groups, ulnar loops were the most predominant pattern (44.45%) followed by whorls (31.2%), arches (22.6%), and the least were the radial loop (1.75%). Ulnar loops were significantly more in females than in males while in the males whorls were significantly higher. These results are in accordance with those obtained by Badawi et al., (2006) who found that the ulnar loop type is the most abundant type. Jaja and Igbigbi (2008) obtained similar results in their work on the digital and palmar dermatoglyphics of the

Ijaw of Southern Nigeria reported that the ulnar loops are the most prevalent digital ridge pattern type, followed by whorls, arches and the least being the radial loops.

In this study, ulnar loops were the predominant ridge pattern among the Egyptian groups, while whorls were more common among the Malaysian groups. The dominant ridge pattern among Egyptian population groups were loops in both males and females, the ulnar loops is the predominant in females.

A cross sectional study of palmar and digital patterns randomly on Zimbabweans, ulnar loop were the most predominant digital pattern type in both sexes followed by whorls in males and arches in females (Igbigbi and Msamati, 2002). In a similar study on Malawian subjects carried out by (Igbigbi and Msamati, 1999) showed that the arches were the most predominant digital pattern in both sexes followed by radial loops in males and whorls in females. This is far apart from findings obtained in the current study reflecting the racial difference as regards frequency of the digital patterns.

## *CONCLUSION & RECOMMENDATIONS*

The results obtained in this paper clarify that gender determination may be a population specific phenomenon in fingerprint recognition. Thus, Combining the factors of race and gender and understanding their effect on fingerprint recognition systems would be important to large scale implementers of this technology. Since fingerprint feature details are different between males and females, it would be interesting to create fingerprint extraction and matching modules which are customized to each gender.

Finally, we recommend establishing a national fingerprinting data base in Egypt. This will help studying the features of fingerprints in Egyptians as well as enhancing multiracial comparative studies on a larger scale.

## *ACKNOWLEDGMENT*

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**Table (1):** Sex wise distribution of epidermal ridges count (RC).

| RC | Males (№ 200) | | Females (№ 200) | |
|---|---|---|---|---|
| | № | % | № | % |
| 10 | 10 | 5 | 0 | 0 |
| 11 | 58 | 29 | 3 | 1.5 |
| 12 | 101 | 50.5 | 2 | 1 |
| 13 | 14 | 7 | 28 | 14 |
| 14 | 10 | 5 | 32 | 16 |
| 15 | 7 | 3.5 | 115 | 57.5 |
| 16 | 0 | 0 | 20 | 10 |
| Total | 200 | 100 | 200 | 100 |

**Table (2):** Range and mean ridge count (MRC) in both males and females.

| Parameter | Males (№ 200) | Females (№ 200) | P value |
|---|---|---|---|
| **Mean RC+SD** | 11.89+1.03 | 14.58+0.97 | **0.001**** |
| **Max RC** | 12 | 15 | |
| **Min RC** | 15 | 12 | |

**P< 0.005 is highly statistically significant. SD: Standard Deviation

**Table (3):** Distribution of Ridge Count among Malaysians versus Egyptians

| No of Ridges | Malaysians (№ 200) | | Egyptians (№ 200) | |
|---|---|---|---|---|
| | № | % | № | % |
| 10 | 4 | 2 | 6 | 3 |
| 11 | 43 | 21.5 | 17 | 8.5 |
| 12 | 40 | 20 | 64 | 32 |
| 13 | 27 | 13.5 | 15 | 7.5 |
| 14 | 21 | 10.5 | 21 | 10.5 |
| 15 | 56 | 28 | 66 | 33 |
| 16 | 9 | 4.5 | 11 | 5.5 |
| Total | 200 | 100 | 200 | 100 |

**Table (4):** Range and mean ridge count (MRC) in Malaysians & Egyptians

| Parameter | Malaysians (№ 200) | Egyptians (№ 200) | P value (>0.05) |
|---|---|---|---|
| **Mean RC+ SD** | 13.11+1.69 | 13.35+1.66 | 0.1528 |
| **Max RC** | 15 | 15 | |
| **Min RC** | 10 | 10 | |

SD: Standard Deviation

**Table (5) :** Sex wise distribution of epidermal ridge count in Malaysians & Egyptians.

| No of Ridges | Males % | | Females% | |
|---|---|---|---|---|
| | Malaysian (№ 100) | Egyptian (№ 100) | Malaysian (№ 100) | Egyptian (№ 100) |
| 10 | 4% | 6 % | 0% | 0% |
| 11 | 41% | 17% | 2% | 0% |
| 12 | 38% | 63% | 2% | 1% |
| 13 | 6% | 8% | 21% | 7% |
| 14 | 6% | 4% | 15% | 17% |
| 15 | 5% | 2% | 51% | 64% |
| 16 | 0% | 0% | 9% | 11% |
| Total | 100% | 100% | 100% | 100% |

**Table (6):** Range and mean ridge count (MRC) in Malaysian males & Egyptian males:

| Parameter | Malaysian males (№ 100) | Egyptian males (№ 100) | P value (>0.05) |
|---|---|---|---|
| **Mean RC+ SD** | 11.84+1.14 | 11.93+0.91 | 0.539 |
| **Max RC** | 11 | 12 | |
| **Min RC** | 10 | 15 | |

SD: Standard Deviation

**Table (7):** Range and mean ridge count (MRC) in Malaysian females & Egyptian females:

| Parameter | Malaysian females (№ 100) | Egyptian females (№ 100) | P value |
|---|---|---|---|
| Mean RC+SD | 14.38+1.10 | 14.77+0.78 | 0.0042** |
| Max RC | 15 | 15 | |
| Min RC | 11 | 12 | |

**P< 0.005 is highly statistically significant. SD: Standard Deviation

**Table (8):** Range and mean ridge count (MRC) in Malaysian females & males.

| Parameter | Malaysian females (№ 100) | Malaysian males (№ 100) | P value |
|---|---|---|---|
| Mean RC+ SD | 14.38+1.10 | 11.84+1.14 | 0.000** |
| Max RC | 15 | 11 | |
| Min RC | 11 | 10 | |

**P< 0.005 is highly statistically significant. SD: Standard Deviation

**Table (9):** Range and mean ridge count (MRC) in Egyptian females & males.

| Parameter | Egyptian females (№ 100) | Egyptian males (№ 100) | P value |
|---|---|---|---|
| Mean RC+ SD | 14.77+0.78 | 11.93+0.91 | 0.000** |
| Max RC | 15 | 12 | |
| Min RC | 12 | 15 | |

**P< 0.005 is highly statistically significant. SD: Standard Deviation

**Table (10):** Sex wise distribution of digital ridge patterns.

| Ridge pattern | Males (№ 200) | Females (№ 200) | Total (№ 400) |
|---|---|---|---|
| Whorls | 44.8% | 17.6% | 31.2% |
| Ulnar loops | 37.7% | 51.2% | 44.45% |
| Radial loops | 2.7% | 0.8% | 1.75% |
| Arches | 14.8% | 30.4% | 22.6% |
| Total | 100 % | 100 % | 100 % |

Table (11): Distribution of digital ridge patterns among Malaysians & Egyptians.

| Ridge pattern | Malaysians (№ 200) | Egyptians (№ 200) | Total (№ 400) |
|---|---|---|---|
| **Whorls** | 50.9% | 11.5% | 31.2% |
| **Ulnar loops** | 26.7% | 62.2% | 44.45% |
| **Radial loops** | 1.2 % | 2.3% | 1.75% |
| **Arches** | 21.2% | 24% | 22.6% |
| **Total** | 100% | 100% | 100 % |

Table (12): Gender based ridge patterns distribution among Malaysians & Egyptians.

| Ridge pattern | Males (№ 200) | | Females (№ 200) | | Total (№ 400) |
|---|---|---|---|---|---|
| | Malaysians (№ 100) | Egyptians (№ 100) | Malaysians (№ 100) | Egyptians (№ 100) | |
| Whorls | 67.8% | 21.8% | 34% | 1.2% | 31.2% |
| Ulnar loops | 19.4% | 56% | 34% | 68.4% | 44.45% |
| Radial loops | 1% | 4.4% | 1.4% | 0.2% | 1.75% |
| Arches | 11.8% | 17.8% | 30.6% | 30.2% | 22.6% |
| Total | 100% | 100% | 100% | 100% | 100 % |

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# تأثير النوع والجنس على نظام التعرف على بصمة الإصبع فى المصريين مقابل الماليزيين

*المشتركون فى البحث*

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وجد ان بصمات الاصابع تتحدد جينيا وهى تقليدية النمط فى تطورها ومختلفة بين مجموعات السكان وداخلها. نتوءات الاصابع واشكال هذه النتوءات هى سمات ادمية وراثية، دائمة وغير متغيرة بتغير العمر وتمت دراستها كنموذج للسمات الكمية فى الانسان لأكثر من ثمانين عاما.

وتهدف هذه الدراسة الى تحديد عدد نتوءات الاصبع وشكلها فى المصريين والماليزيين لتوضيح الفروق بينهما وتحديد تأثيرات النوع فى المجموعتين.

احتوت الدراسة على ٤ مجموعات من المصريين والماليزيين من النوعين اشتملت كل مجموعة منها على ١٠٠ شخص، كلهم اصحاء اعمارهم بين ١٨-٢٢ سنة.

واخذت بصمات اصابع اليدين لكل شخص وتم تحديد عدد النتوءات فى مساحة ٢٥ مم ٢ مع تقدير شكل النتوءات. وعمل التحليل الاحصائى بالرجوع الى النوعين فى كلا المجموعتين.

واظهرت النتائج اختلاف عدد النتوءات فى المصريين عن الماليزيين حيث كانت اقل عددا فى الذكور عنها فى الاناث وكان حوالى نصف العينة من الذكور لديهم عدد ١٢ نتوء ولم يسجل اى ذكربعدد نتوءات اكثر من ١٥ نتوء.

وعلى الجانب الاخر، لم توجد لاى انثى ١٠ نتوءات وقد وجدت فروق ذات دلالة احصائية عالية فى عدد النتوءات بين المصريات والماليزيات بينما لم تسجل فروق ذات دلالة احصائية بين الذكور المصريين والماليزيين.

اما اشكال النتوءات فقد سجلت اختلافا ذا دلالة احصائية بين النوعين فى كلا المجموعتين محل الدراسة حيث كانت الحلقات الزندية اكثر بصورة ملحوظة فى الاناث عنها فى الذكور بينما كثر الشكل الحلزونى فى الذكور.

كانت الحلقات الزندية هى الاكثر بين المصريين بينما كان الشكل الحلزونى هو الاعم بين الماليزيين.