Original Article

DISTRIBUTION OF FINGERPRINT PATTERNS AMONG YOUNG ADULTS AND SIBLINGS IN MALAYSIA

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ABSTRACT

A study was conducted to study the distribution of fingerprint patterns among Malaysian population, specifically on the right and left hands, gender, major ethnic groups and siblings. A total of 192 subjects in the age of 14 and above were involved. For public citizen, 96 subjects were selected from University Kebangsaan Malaysia Kampus Kuala Lumpur (UKMKKL) while 96 siblings were recruited from families around Kuala Lumpur. Ten fingerprints were collected from each subject and the pattern was classified into whorls, loops, arches and composites patterns. The study revealed the most likely fingerprint patterns to occur on a specific finger as well as in a specific ethnicity. Fingerprint patterns were dependent upon the finger on which they occur. Statistical analysis indicated that right and left hands could be distinguished by whorl pattern. However, fingerprint patterns did not show any differences between males and females. Loops and whorls were the most predominant pattern in all studied ethnic groups. Malays and Chinese had similar distributional patterns which was different with Indians. Fingerprint patterns showed a significant difference among three major ethnic groups ($p < 0.01$) especially on the left and right thumb, right index as well as right middle finger. Siblings demonstrated greater similarity of all fingerprint patterns than non-siblings except for the arch pattern. The present study suggested that fingerprint pattern could be inherited genetically but not linked to sex chromosome.

INTRODUCTION

Among all the methods of identification, fingerprint has proved to be both infallible and feasible. Its superiority over the older methods, such as branding, tattooing, distinctive clothing, photography, and body measurements, has been demonstrated time after time [1]. So far, fingerprints have been used for more than 100 years as the most popular biometric signs of identity in both civil and criminal cases because of their unique properties of absolute identity [2]. It has been estimated that chances of two persons having identical finger impression is about one in sixty four thousand million population of the world. Identical twins share the same DNA profile, yet their fingerprints are as distinctive as any unrelated persons. Therefore, no two fingers are found to have identical prints [3].

The ridge patterns are formed in the human fetus before birth and remain the same throughout a person's life except in the case of accidents, such as bruises and cuts on the finger tips [4, 5]. Anyway, fingerprints remain the same even after small cuts or abrasions affecting the skin surface because the skin's regeneration was based on the original dermis pattern. Only deep cuts that damaged the dermis will result in a permanent scar [6]. The patterns of fingerprints become fixed when a person is about 14 years or older [7].

Fingerprint classification refers to the problem of assigning a fingerprint to a class in a consistent and reliable way. Fingerprints are made up of a number of easily recognizable features that permit them to be classified and filed for later reference [8]. It is an important indexing scheme to narrow down the search of fingerprint database for efficient large-scale identification. Therefore, the identification process can be speeded up by reducing the number of comparisons that are required to be performed. However, it is still a challenging problem due to the intrinsic class ambiguity and the difficulty for poor quality fingerprints [9]. Most of the classification schemes currently used worldwide is variants of Henry's classification scheme which include four most common classes of fingerprint, i.e. arch, loop, whorl and composite [10].

Even though every fingerprint pattern occurred in every ethnic, some fingerprint patterns noticeably dominant in some ethnic group than the others did. For instance, whorl is the most dominant pattern in fingerprint of Asians. On the other hand, there is some correlation between both the class and minutiae-based similarity between the fingerprints of parents and their children, and the same pattern was also observed for identical twins. The similarity between the fingerprints of siblings was found to be higher than that between those of parents and their children [4].

The purpose of this research is to study the distribution of fingerprint patterns among Malaysians, specifically on public citizen and siblings. There are no studies available on the distributional pattern of fingerprint for siblings in Malaysian population. In Malaysia, there are three major ethnic groups which are Malay, Chinese and Indian as well as other minorities such as Iban and Kadazan. The three major ethnic groups in Malaysia were selected to be participated in this study. The population in Malaysia now is constituted of 65.1% of Malay, 26% of Chinese, 7.7% of Indian and the balance 1.2% containing others minority groups [11]. Thus, the ratio of each ethnic selected is representing Malaysian population.

MATERIALS AND METHODS

The study was conducted on 192 subjects aged from 14 years old and above [7]. For public citizens, 96 subjects were chosen randomly from Universiti Kebangsaan Malaysia Kampus Kuala Lumpur (UKMKKL) with 64 Malays, 25 Chinese and 7 Indians. To be confirmed as Malaysian, subject was asked to present their Malaysian Identification Card (Mykad). Another 96 siblings were chosen randomly around Kuala Lumpur. Only those siblings with blood relationship in a family were allowed to take part in this study. A total of ten fingerprints were taken from each subject by using *Perfect Ink PI-10* (Identicator Inc, California). Individuals that have at least three generations of same ethnic group marriage were included and those who are not were classified as “unpure” and omitted. On the other hands, subjects with any evidence of disease and injury of the fingertips that are likely to alter the fingerprint pattern such as leprosy, scars of the fingertips and lacerations were excluded. Only those with ten fingers were included in this study.

This study was approved by UKM ethics committee prior to commence of the study. Consent was obtained in writing prior to the collection of the samples using black ink and white paper method. Subjects were asked to wash and dry their hands to remove dirt and grease. They were then asked to roll the finger pads very gently on the ink pad and then let the researcher to roll it slowly and very gently on the form with labels. The subject was asked to keep his/her arm relaxed and not to try to help in rolling the fingers as this may cause smudging.

The fingers were always rolled away from the body of the subjects [3]. Besides, the fingers were rolled from side to side in order to obtain all available ridge detail [1]. Hence, the ten prints were taken individually – thumb, index, middle, ring and little fingers of each hand in the order named. The pattern of each fingerprint was then determined by researcher with the aid of a hand magnifier *Armor Forensics* 5-1000 (Lightning Powder Co., Germany). The patterns used in this study included arch, loop, whorl and composite [6].

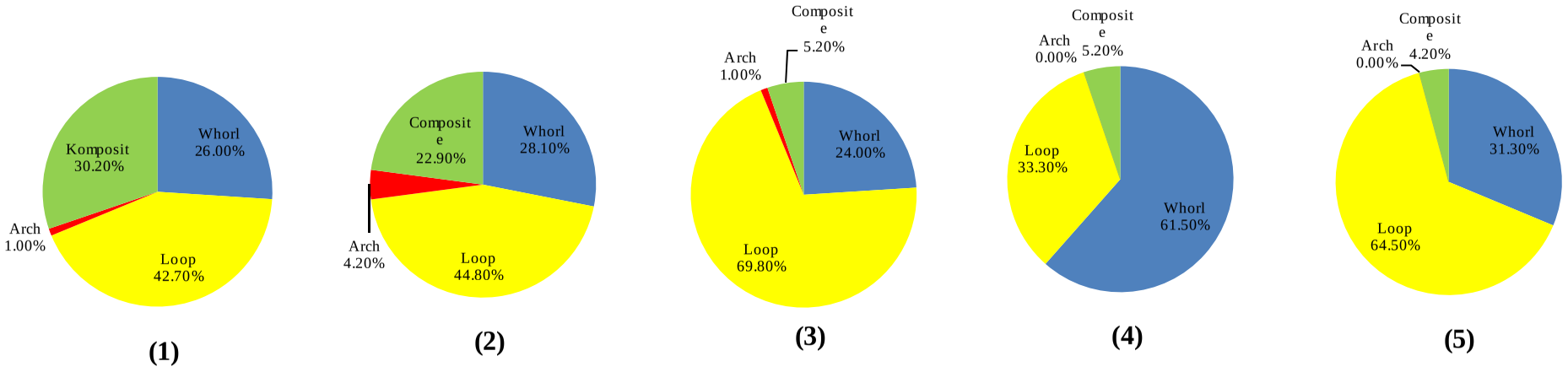
The data were then subjected to statistical analysis by using Statistical Package for Social Science (SPSS) 23.0. Mann-Whitney U test was used to determine the presence of significant difference of fingerprint pattern between right and left hands. In addition, the differences of fingerprint pattern between gender as well as its similarity among siblings and non-siblings were determined by the same test. On the other hand, Chi-Square test for independence was used to study the distribution of fingerprint pattern among races in Malaysia.

RESULTS

Digits were numbered according to Henry’s classification system in which 1 to 5 were designated for fingers on right hand while 6 to 10 for the left hand arranged accordingly from thumb to little finger [3]. Figure 1 shows the distribution of fingerprint patterns across all the fingers among Malaysian. On the whole, loop was the most frequent fingerprint pattern. Notwithstanding this, frequency of loop pattern was the highest on little fingers and followed by middle fingers from both hands. Whorl pattern was most noticeably observed only on ring fingers from both hands. In contrast, arch pattern was rarely observed across all the fingers with the highest percentage of merely 5.2% on index finger from left hand. In addition, ring fingers and little fingers did not show any presence of arch pattern. As regard to composite pattern, thumb and index fingers from both hands indicated the most evident frequency compared to other fingers.

The distribution of fingerprint patterns for left and right hands was showed in Table 1. Overall, both hands demonstrated the same distribution pattern arranging from the highest to the lowest frequencies accordingly i.e., loop, whorl, composite and arch pattern. The frequency of loop, arch and composite pattern was greater on left hand while the right hand showed higher frequency of whorl pattern. The output of statistical analysis showed that frequency of whorl pattern was statistically significant different ($p < 0.05$) between left and right hands. In contrast, both hands showed no statistically different ($p > 0.05$) for loop, arch as well as composite pattern.

Right hand



Left hand

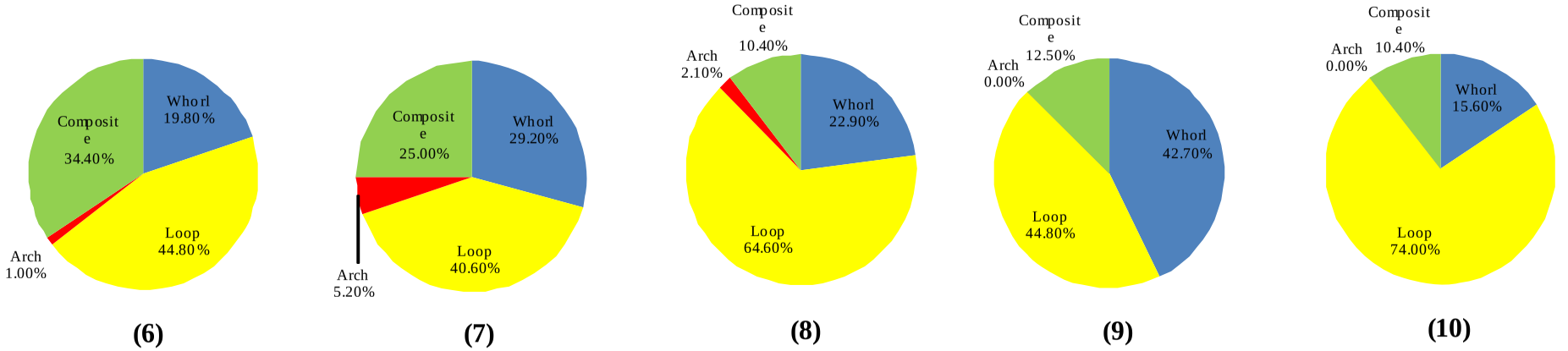


Figure 1: Distribution of fingerprint patterns across all fingers

Table 1: Percentage of fingerprint patterns for public citizens

Fingerprint Patterns	Hands (%)		Genders (%)		Races (%)		
	Left	Right	Males	Females	Malays	Chinese	Indians
Loop	53.75	51.04	48.14	55.85	55.30	43.20	58.60
Whorl	25.83	33.96	32.80	27.74	28.60	36.00	22.90
Composite	18.75	13.75	17.91	14.72	15.30	20.00	8.60
Arch	1.67	1.25	1.16	1.70	0.80	0.80	10.00

With regard to gender, the distribution of fingerprint pattern was showed in Table 1. Male and female possessed the same distribution pattern. In spite of this, male displayed the greater occurrence of whorl and composite pattern whereas female showed the higher frequency of loop and arch pattern. Regardless of this, the frequency differences of fingerprint patterns was vague among the gender. With statistical analysis, the relationship of the fingeprint patterns and the gender failed to be significant ($p > 0.05$).

In respect of the ethnic groups, the frequency distribution of fingerprint patterns was showed in Table 1. Similar distribution pattern was observed in Malays and Chinese. In other words, Indians showed different distribution pattern if compared with Malays and Chinese. Apparently, percentage of loop pattern was extensively greater than the other patterns especially for Malay and Indian. Whorl pattern was the most frequent to be observed after loop pattern. All races demonstrated high frequency of whorl pattern with the highest being observed in Chinese. Percentage of arch pattern was markedly high in Indian (10%) by comparing with Malay (0.8%) and Chinese (0.8%). Moreover, composite pattern was present in every ethnic groups with the greatest frequency in Chinese. As a whole, Malay showed a moderate frequency of fingerprint pattern in comparison with the other studied races.

In accordance with statistical analysis using the chi-square test, there was significant difference ($p< 0.01$) in distribution of fingerprint patterns in all ten fingers among three major ethnic groups in Malaysia. Statistically, the alpha level of less than 0.01 resulted in a high dependency between fingerprint patterns and ethnic groups. Furthermore, pattern frequency on four out of ten fingers had been proved to be significantly different ($p < 0.05$) among the ethnic groups. The mentioned fingers including left and right thumb, right index as well as right middle finger. On the other hand, Malaysian population demonstrated 30.10% whorl, 52.40% loop, 1.50% arch and 16.00% composite pattern. Loop and whorl patterns were the most dominant pattern followed by composite and arch patterns in Malaysian population.

The average of similarity for fingerprint pattern had been compared between siblings and non-siblings group. The distribution of similarity was showed in Figure 2. Generally, similarity of all studied patterns was greater and manifest in siblings in comparison with non-siblings. The output of statistical analysis showed that there was a significant different ($p< 0.05$) of similarity for all the studied patterns between siblings and non-siblings with the exception of arch pattern ($p > 0.05$).

DISCUSSIONS

The findings for distribution of ten fingerprints were in agreement with the studies by Swofford (2005) and Nithin et al. (2009) [3, 12]. This study revealed that fingerprint pattern was dependent upon the finger on which they occur. Despite the fact that every fingerprint pattern occurred on every finger, some fingerprint patterns noticeably dominated specific fingers more than others did. With the outcome of present study, the fingers on which the fingerprints occur can be predicted in order to expedite the comparison of latent prints found at crime scene to known ten prints database. This can be done by narrowing the search parameters as to the most likely finger before comparison.

The findings of same distribution pattern for both hands were in agreement with Endom et al. (2009), Narahari & Padmaja (2006) and Nithin et al. (2009) [3, 13, 14]. In addition, the findings of pattern frequencies on right and left hands were in agreement with Narahari et al. (2008) [15]. However, Segura-Wang & Barrantes (2009) reported a different findings [16]. The difference could be due to different target population which may showed dissimilar distribution of fingerprint patterns.

This study revealed that both right and left hands may be differentiated through the pattern of whorl. This findings partially supported previous studies saying that fingerprint patterns and the hands on which they occur were not dependent upon each other [12, 17]. In fact, along with bilateral symmetry of both hands, there could be a relatively equal number of the same fingerprint patterns occuring on the two hands [12]. Moreover, fingerprint patterns on an individual's left and right hands were often

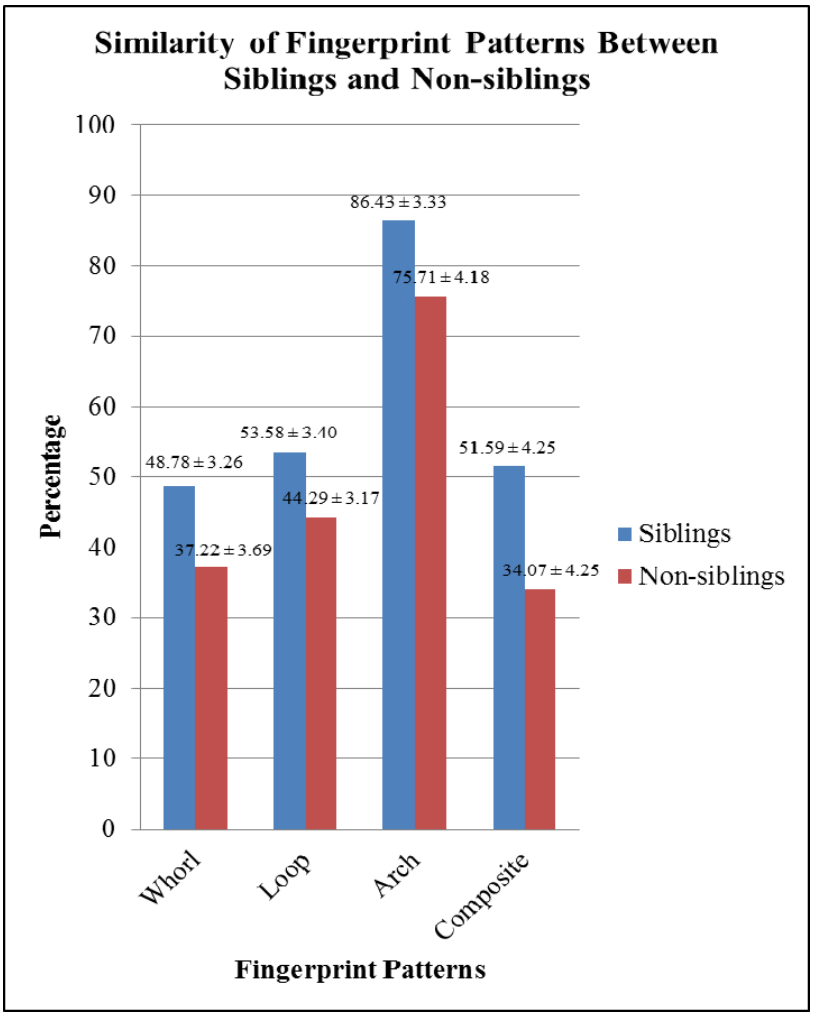


Figure 2: Similarity of fingerprint patterns between siblings and non-siblings

similar to mirror image of each others. This was due to the genetic basis for volar pad formation [18]. Nevertheless, the percentage differences of every single patterns was indistinct as a whole.

The same distribution pattern between males and females was in agreement with Gutiérrez-Redomero et al. (2010) [19]. Regarding the pattern frequencies among genders, a number of previous studies reported the similar findings with the present study [3, 15, 20-23]. This tendency was probably indicative of the modulatory influence of genes on the segments of the sex chromosomes have on the several ontogenic processes regulating ridge pattern morphogenesis in utero [20].

Fingerprint patterns and the gender on which they occur were not dependent upon each other. Hence, the present study revealed that gender could not be differentiated by using fingerprint patterns. The findings were in agreement with [13, 14, 19, 22, 24]. With respect to the findings, it suggested that fingerprint pattern did not inherited genetically via chromosome Y. If the gene determination for fingerprint pattern was located on chromosome Y, it was very likely that higher frequency of certain fingerprint patterns can be observed on male. Furthermore, with no significant different among gender, it could also proposed that fingerprint pattern did not inherited genetically via sex chromosome. Nonetheless, further study on this is necessarily to confirm the reliability of the fact.

With regard to ethnic groups, the findings of similar distribution pattern among Malays and Chinese were in agreement with previous similar study on Malaysian population by Endom et al. (2009) [13]. The present study revealed that even though every fingerprint pattern occurred in every race, some fingerprint patterns markedly being observed in some races more than the others. Sharma et al. (2008) [25] and Endom et al. (2009) [13] reported the similar findings with the present study in which races could be differentiated by fingerprint patterns. It is concluded that races could be differentiated by fingerprint patterns in regard to genetic variation among different races in Malaysia [13]. Sharma et al. (2008) [25] also suggested that differences of fingerprint features might be according to the genetic differences among the studied populations, characterized by different geographical conditions, ethnicity and linguistic backgrounds.

With respect to the significant different among ethnics, it is proposed the usage of these four specific fingers to discriminate major ethnics in Malaysia. Despite the fact that fingerprint pattern could not be used to identify individual, it may reduce the database search scope and further decrease the necessary comparison to be proceed [9]. For instance, timesaving database searching can be achieved by identifying or narrow down the race for fingerprint pattern which was found at crime scene. In this manner, this could possibly increase the effectiveness in solving the criminal cases in the country.

The similar distribution pattern with Malaysian population had been reported in a number of previous studies [13, 26, 27]. The fingerprint patterns were predominantly affected by two combined timing events i.e., the onset of epidermal cellular proliferation and the timing of the regression of the volar pads [12]. Early ridge formation was associated with whorl, later formation with arch, and intermediate formation with loops [28]. Since loop was the most dominant pattern, it can be concluded that fetus from Malaysian population has the onset of ridge proliferation during the middle stages of volar pad regression while the volar pad is most likely asymmetrical.

Because of the genetic basis for the formation of volar pad, overall ridge flow or pattern classification is often similar between siblings, especially identical twins [18]. On the other hand, siblings shared 50% of their genetic information [29, 30] while non-siblings did not share any of their genetic material. For this reason, the present study revealed that fingerprint pattern may be inherited genetically with the greater similarity of patterns among siblings. Rastogi and Pillai (2010) [23] reported that there was a strong assocsiation between human blood group with fingerprint patterns. In actual fact, people inherit two genes for blood type or more accurately two alleles, one from each parents, which determine the blood type [31]. Hence, it suggested that fingerprint pattern was indirectly inherited genetically from parents.

The statistical outcome may indicates that siblings and non-siblings could be distinguished by similarity of whorl, loop and composite patterns on their fingers. Although the similarity of arch pattern was higher among siblings, it was not statistically different with similarity among non-siblings. Notwithstanding this, its significant level ($p = 0.054$) was very close with the border line of significance ($p = 0.05$). This could probably due to insufficient sample size to show its significance.

CONCLUSION

The most predominant pattern among Malaysian population was loop, followed by whorl, composite and arch. Fingerprint patterns were dependent upon the finger on which they occur. Right and left hands could be distinguished by whorl pattern. Irrespective of the gender, fingerprint patterns did not show any difference. It is suggested that fingerprint pattern can be used to narrow down the races in Malaysia especially left and right thumb, right index as well as right middle finger. Siblings showed greater similarity of all fingerprint patterns than non-siblings except for the arch pattern. Fingerprint pattern could be inherited genetically but not linked to sex chromosome.

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