Jurnal Biosains Pascasarjana Vol. 24 (2022) pp

AN UPCOMING FORENSIC TOOL: DIFFERENCES OF THE NUMBER OF FINGERPRINT WHITE LINES AS SEX DETERMINATION IN YOGYAKARTA

Salsabila Hajjah Algani[1]
[1]Sekolah Pascasarjana Universitas Airlangga
*[1]e-mail : salsabilalgni@gmail.com

Abstrak

Identifikasi forensik atau identifikasi personal merupakan upaya untuk menentukan identitas seseorang termasuk penentuan jenis kelamin. Pengambilan sidik jari dalam metode identifikasi memiliki tingkat keakuratan yang paling tinggi. Penentuan jenis kelamin berdasarkan jumlah garis putih sidik jari (Fingerprint White line Count) belum dijelaskan dengan baik didalam literature. Penelitian ini dilakukan untuk menentukan adanya perbedaan jenis kelamin berdasarkan jumlah garis putih sidik jari pada populasi di Yogyakarta. White lines dapat dipengaruhi oleh banyak hal seperti ras, usia, indeks massa tubuh, kebiasaan, dsb. Oleh karena itu perlu dilakukan penelitian untuk melihat apakah terdapat perbedaan yang signifikan pada jumlah white line sidik jari antara kedua jenis kelamin pada populasi di Yogyakarta. Penelitian ini bersifat observasional analitik dengan pengambilan sampel menggunakan metode random sampling test dan dilakukan dalam sekali waktu (cross sectional). Terdapat 460 partisipan (230 laki-laki dan 230 wanita) yang ada di Yogyakarta. Sidik jari diambil dengan menggunakan metode ink yang diamati secara langsung menggunakan kaca pembesar untuk menghitung white line pada sidik jari. Pengamatan dilakukan dengan menghasilkan adanya perbedaan yang signifikan pada jumlah white lines dengan nilai p = 0.000 antara laki-laki dan perempuan di Yogyakarta.

Kata Kunci: Identifikasi forensik, sidik jari, garis putih, penentuan jenis kelamin

Abstract

Forensic identification or personal identification is an attempt to identify a person one of which is sex determination. The fingerprint is one of the identification methods that have the highest level of accuracy compared to other methods. Sex determination based on using of fingerprint white line counts has not been well described in the literature. This study was conducted to determine the existence of gender differences based on fingerprint white lines counts in Yogyakarta. Fingerprint white lines is associated with other factors such as race, age, body mass index, habits, etc. Therefore it is necessary to conduct research to see whether there is a significant difference in fingerprint white lines counts between gender of population in Yogyakarta. This study is an observational analytic, the sampling method is stratified random sampling and the data obtained in one time (cross-sectional). There were 460 participants (230 men and 230 women) in Yogyakarta. Fingerprints were taken using the ink method which was observed directly using a magnifying glass. Based on the data analysis, there are a significant difference of fingerprint white line counts (p = 0.00) between men and women in Yogyakarta.

Keywords: forensic identification, fingerprints, white lines, sex determination

1. INTRODUCTION

Forensic identification is an effort that can be done to determine the identity of a person, both a victim and a perpetrator of a crime. Identification can be done in three ways, namely visually (by looking directly), detailed data (eg ante-mortem data that matches the information collected during the autopsy process and other information) and scientifically included in dental examinations, DNA and fingerprints. One of the methods used in identifying a person with fingerprints is using the template matching. This method does not take a long time and is somewhat faster than identification using DNA. In determining the identity of a person with fingerprints is usually done by the police. Even so, doctors have an obligation to take and print fingerprints, especially on victims who died with decomposed bodies (Adelia, et al., 2018).

When at a crime scene evidence is found in the form of fingerprints, the examination is relied upon to be able to compare the prints obtained manually with those stored in the database. But the fact is that this professional analysis is accurate but not perfect, as in other fields that require high risk decision making. So to compensate for or avoid a critical error, namely by providing evidence other than fingerprint examination. Decision making in the fingerprint examination process also needs to be considered, so that decision making is best done based on a combination of independent assessments from a small group of fingerprint analysts so that it can improve performance and prevent errors such as wrong results which can harm many people when the error has gone to court (Tangen, JM, Kent, KM, Searston, RA, 2020).

Fingerprint ridges for identification purposes are based on the distinctive stroke lines that appear within the coating of the fingertips and thumb. In addition, the identification method with fingerprints has proven to be feasible and perfect because until now no identical fingerprint patterns have been found between one individual and another (Abdullah, Rahman, and Abas, 2015). The pattern of the fingerprint epidermal ridges depends on the cornified layer of the epidermis and the configuration of the dermis. Pattern epidermis ridge occurs during the 10th to 16th week of uterine life (Babler, WJ, 1991); (Hale, A., 1951); (Penrosa, LO, 1973). The basal layer consists of columnar epithelium into waves which will result in the formation of folds of the epidermis into the dermis which is called the primary ridge which later forms a fingerprint pattern on the surface (Okijima, 1975) and (Kucken, 2004). Configuration ridge Fingerprint epidermal ridge, minutiaedensity ridge, ridge porescontours ridge and shape, all of which have a degree of acceptance as features in forensic science as personal identities. In addition to these features, areas of hypoplastic ridges that become visible to the point of appearing white in fingerprint capture will result in ridges associated with features called “white lines” (D'Adamo, 2010).

White lines are skin folds on ridge that appear as white lines on prints, and their frequency will increase later in life or when subcutaneous body fat changes (Ashbaugh, 1999; Cummins and Midlo, 1943: Taduran., et al, 2015).

Reference population data is needed to complete the available data on fingerprint white lines counts (FWLC). The potential for determining sex needs to be investigated to strengthen the evidence obtained from the literature regarding the possible application of FWLC in determining identity, especially in determining sexuality (Champod, et al., 2004). Fingerprints have been used in the fields of anthropology, genetics and forensics since the 3rd century BC (Dhall and Kapoor, 2016).

Gender identification is an important step that is carried out because of the interest in uncovering a truth. The fingerprint feature that has been found at the crime scene has proven to be a very useful indicator in the investigative process by investigators. Potential features of fingerprints such asridge densityhave been introduced for sex inference since the existence of a quantitative average value of the number ridges per unit area (Acree, 1999).

According to Badawi et al, (2006) stated that the calculation of white lines can be relied upon as a method for determining sex using fingerprints, with women having more white lines than men. So that previous research demonstrated that when applying the number of white lines on fingerprints as a feature for sex inference, women have more white lines than men on the right and left fingerprints (Badawi, A., et al., 2006) and (Adamu, LH, et al., 2019).

Apart from the use of fingerprints in forensic identification to determine a person's identity, identification based on ridge density, the fingerprint white lines in determining gender get different results based on research that has been conducted in various countries without known causes. what we can be certain of is. Therefore, further studies are needed to find out whether there are significant differences between women and men in the number of white lines in the population in Yogyakarta.

2. RESEARCH METHODS

2.1 Sampling

The research was conducted at INAFIS Yogyakarta Special Region Police, Indonesia for 3 months, from October 2021 to January 2022. This study used simple random sampling with a total of 460 people (230 men and 230 women) with an age range of 18-30 years. The inclusion criteria included participants without physical disabilities in one of the fingers.

Fingerprint data collection was carried out by the Yogyakarta Special Region Police INAFIS to maintain the accuracy of the calculations, and was approved by the Yogyakarta Police Head of Identification based on the approved protocol for research sampling.

This research is a cross-sectional study that involves collecting biodata such as gender, age and ethnicity. Fingerprint calculations supervised by the Yogyakarta Police INAFIS (Polda DI Yogyakarta) to maintain the accuracy of the count.

Test data distribution analysis using the Kormogorov-Simirnov and followed by using the Mann Whitney U test, adjusted for the distribution of research data. The significance value used is 0.05, which means that the tolerance for error to accept or reject the hypothesis is 5%.

2.2 White lines Counts

2.2.1 Fingerprint Fingerprint

There are three classifications of fingerprint patterns, namely whorl, loop and arch. (can be seen in Figure 1) (Taduran, 2018).

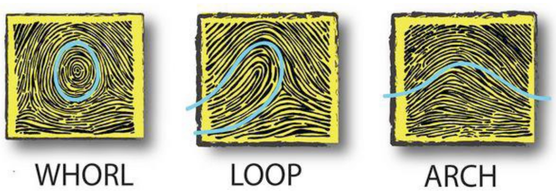
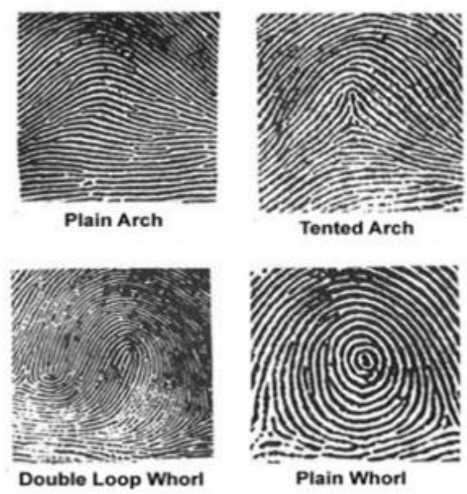


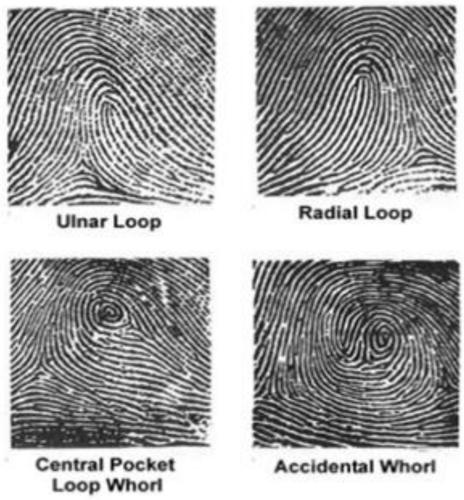
Figure 1. Classification of fingerprint patterns.

Arch is a dermatographic pattern that has the form of curved parallel lines like an arc formed by the epidermal ridges. patterns Arch are divided into two, namely plain arches and tented arches. Plain arches have the main form of painting only, where the lines from one side of the painting flow towards the other side with a slight wavy up in the middle. Tented arch has a shape with lines that from one side of the painting to the other has a right angle in the middle, one or more lines will stand straight up in the middle.

The loop shape has one delta which is its characteristic, has a core and has a line connection of at least one line and curved lines. The loop itself has two types, namely the ulnair loop which has a shape on the right fingerprint that has a delta on the right. Meanwhile, the radial loop has a fingerprint shape where the delta position is on the left.

This whorl shape has two deltas, where if drawn with an imaginary line from the two deltas there will be at least one line that is circular and forms an oval, spiral circle in front of the two deltas. The whorl pattern is divided into five, namely plain whorl, twinted loop, lateral packet loop, central pocket loop, accidental (special pattern) which has a fingerprint shape with two mixtures, namely the main fingerprint shape and two or more deltas. The shape of the fingerprint pattern can be seen in Figure 2 (Badawi, et al., 2006).





Gambar 2. Pola - pola sidik jari

Latent fingerprint matching is carried out using unique features with categories divided into three levels, namely level 1, level 2, level 3, can be seen in **Figure 3** (Dhaneshwar, R., et al., 2021).

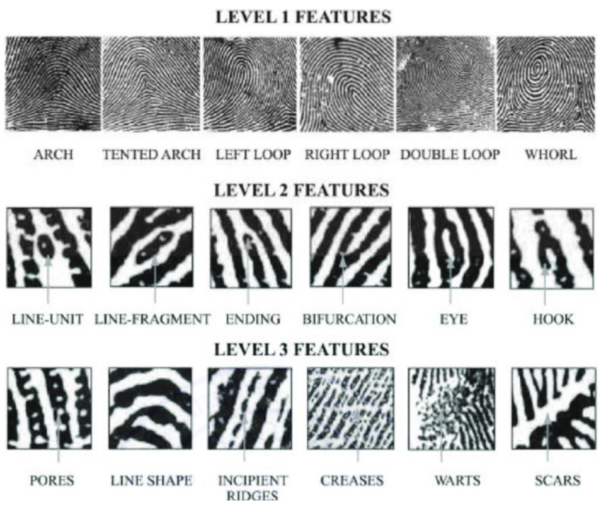


Figure 3. Different feature levels in latent fingerprints

At level 1 features in fingerprint matching are the most basic features that can be derived from latent fingerprint samples such as arch, left loop, right loop, whorl, etc., which are visible to the naked eye or do not require any tools. Then, at level 2 features consisting of ridge endings, bifurcations, hooks, etc. However, when the quality of the evidence is poor, these features may not be extracted efficiently, therefore proper reconstruction and improvement is needed to eliminate spurious features. At feature level 3 is the most decisive feature in improving good performance. These are permanent features that we can restore from samples like pores, line-shape, scars, etc. Although usually there will be constraints, namely the resolution, so usually a combination of these features is used for the appropriate matching results.

Ridge Count (RC) is defined as the number of ridges that touch a straight line between two fixed points, namely the triradii, or triradius and core . The method used to obtain the number of ridges that are not affected by finger patterns can be seen in Figure 4.

The triradius is first identified for each fingerprint, then a one-centimeter line from the triradius towards the nucleus is drawn and the number of bumps touching the line is counted. In prints without a triradius, i.e. molds with strategic ridge patterns are selected as long as the lines are perpendicular to the ridges. In prints with more than one triradius, namely prints with a circle pattern, a triradius with a higher number of ridges is selected (Taduran, 2018).

Figure 4. The ridge count on the fingerprint pattern from left to right arch, loop, whorl..

2.2.2 White lines

The calculation of white lines is determined according to the method in previous studies as skin folds in the friction area that appear as white lines on fingerprints (Taduran, et al, 2015). White line count is considered when more than one epidermal ridge is crossed by the white line regardless of the direction and orientation of the white line. The number of white lines per unit of

DOI 10.20473/jbp.v24i2.2022.86-97

fingerprint will be counted as the number ofwhite lines (Adamu, Asuku, Muhd., et al, 2019). In Figure 5, an example of calculating the number of white lines on male and female fingerprints

Figure 5. Fingerprints (left: male and (right: female), showing a higher number of white lines in females than males.

Fingerprint examination is divided into two, namely qualitatively and quantitatively. Qualitative examination is assessed from the type of fingerprint pattern. Based on the classification of fingerprint patterns, they are divided into arch, loop, whorl. Then the quantitative examination will be assessed from TPI (Total Pattern Intensity), DI (Dankmeijer Index), FI (Furuhata Index) and TRC (Total Ridge Count).

2.3 Statistical Analysis

Data are expressed in mean ± SD.data were not normally distributed (Kormogorov-Simirnov) with a p <0.05 which indicated that a non-parametric test was necessary, namely the Whitney to see if there was a significant difference in Fingerprint White Lines Counts (FWLC). Statistical analysis used SPSS version 19 (IBM Corporation, for windows) for data analysis with a p <0.05 set as the significance level.

4. RESULTS AND DISCUSSION

When fingerprints are found at a crime scene, the process of identifying individuals using fingerprints will use a computer algorithm to compare the prints with dozens of data that have been stored in a database. This algorithm will produce a list of potential candidates, sorted from the most similar to the least similar, along with their level of similarity. Fingerprints are different from each other so that fingerprints are unique, even identical twins have different fingerprints (Srihari, Srinivasan, and Fang, 2008).

Check with this algorithm with preset detection in comparing the fingerprint with the overall pattern and print direction as well as other details such as ridge edges, bifurcations, contours, dots, folds, islands, breaks, pores, enclosures. When the examiner has identified a number of suitable features to further convince the identification process that the two prints come from the same person, usually the presentation of the similarity level in the system is above 90%, above 80% should be explored again in the identification process, then the final "verified" decision will be enter into a computer algorithm system (Thompson, et al., 2017).

Despite the fact that fingerprint checks have been shown to have excellent performance (Searston and Tangen, 2017a; Searston and Tangen, 2017b; Tangen, Thompson and McCarthy, 2011; Thompson and Tangen, 2014; Ulery, et al., 2011) , mistakes still occur in the past (Cole, 2005).

A process of personal identification will be very important and very dependent on the inspection process of an examiner whether it is in accordance with the proper procedures to produce actual results. Correct identification means being able to distinguish between acquitting someone who should be guilty or punishing an innocent person. So that a forensic analyst has to work hard to catch the real criminals and uphold civil liberties, so forensic analysts have a very high workload (Tangen, et al., 2020).

There are other things, such as abnormalities in fingerprints, that can hinder the process of personal identification. Such Adermatoglyphia and possible fingerprint changes have serious medicolegal implications. Adermatoglyphia itself is the absence or loss of fingerprints, this condition does occur very rarely which is often referred to as "immigration delay disease" (Villacorta, 2011). Loss of fingerprints is usually associated with Hand-foot syndrome (palmar-plantar erythrodysesthesia or palmoplantar erythrodysesthesia or chemotherapeutic agents (Al-Ahwal, 2012).

According to research from Cohen (2017) states that adermatoglyphia is associated with taking breast cancer drugs, namely Capecitabine, a prodrug Oral 5-fluorouracil, in other cases also occurred (Chavarri-Guerra and Soto-Perez-de-Celis, 2015) (Mazza, et al., 2017). According to Nousbeck, et al., (2011) found that the SMARCAD1 gene which is associated with loss of fingerprints thus suggesting that abnormalities in fingerprint loss are a phenomenon of the presence of a specific SMARCAD1 isoform mutation. In addition to adermatoglyphia, atrophy and changes in the epidermal ridges can be seen in cases of celiac disease, dermatitis, leprosy and after radiation exposure (Kanchan, T ., and Krishan, K., 2018).In this study there were 460 population samples in Yogyakarta, the number of samples obtained was male ki as many as 230 people while in the female sex there were 230 people. The research sample has an age range of 18-30 years where the most age is 21 years as many as 75 people (16.3%) followed by ages 24, 22.25 and 26 years, can be seen in Table 1.

Table 2. Age frequency in the research sample

	Frequency	%	*Valid Percent*	*Cumulative Percent*
18.00	4	0.9	0.9	0.9
19.00	6	1.3	1.3	2.2
20.00	71	15.4	15.4	17.6
21.00	75	16.3	16.3	33.9
22.00	54	11.7	11.7	45.7
23.00	41	8.9	8.9	54.6
24.00	55	12.0	12.0	66.5
25.00	44	9.6	9.6	76.1
26.00	44	9.6	9.6	85.7
27.00	24	5.2	5.2	90.9
28.00	20	4.3	4.3	95.2
29.00	22	4.8	4.8	100.0
Total	460	100.0	100.0	

Table 2 states the age frequency in the study sample was 460 with 230 each for males and females. The age range in this study was at most 21 years old (16.3%) followed by 20 years, 24 years, 22 years. The difference in this range can be seen to find out whether there are other factors that affect the formation of fingerprint white lines such as age, race and body fat according to research from Taura, *et al*., (2019) that there is an effect on the number of white lines due to age, race and body fat.

Calculations were performed using three counting chambers, namely radial, ulnar, and proximal for each finger. After determining the results of the calculation of the *white lines* on the ten fingers, they are added up and the average value is sought.

The white lines are determined as skin folds on the friction protrusions that appear as white lines on fingerprints using *ink* taken by the Yogyakarta Police INAFIS which will later be printed on *form* that has been determined by the police as a fingerprint data base. Regardless of the orientation and direction of the white line, later the white line will be counted when it crosses more than one epidermal ridge as in **Figure 5**. FWLC on each digit is considered as the number of white lines observed per fingerprint unit (Taduran, *et al*., 2016).

Data distribution analysis used the *Kolmogorov-Smirnov test*, showing the average distribution of the number of *white lines fingerprints* abnormal **Table 2**. Therefore, to find out there is a significant difference using a nonparametric test, namely the *Mann-Whitney*.

Table 2. The results of the data distribution are not normal.

One-Sample Kolmogorov-Smirnov Test

		JUMLAH_ PERORANG
N		460
Normal Parameters[a,b]	*Mean*	29.9543
	Std. Deviation	21.81583
Most Extreme Differences	*Absolute*	.085
	Positive	.064
	Negative	-.085
Kolmogorov-Smirnov Z		1.820
Asymp. Sig. (2-tailed)		.003

a. Test distribution is Normal.
b. Calculated from data.

Hypothesis test Mann-Whitney carried out to look for differences in the average number of white lines with non-normally distributed data. Based on the results of the analysis, the results obtained are that the median value of the average white lines in the male sex is 17.5 with a standard deviation value of 16.11683 and in the female sex is 37, with a standard deviation value of 22.71466. Then the median value in the total data is 27 with a standard deviation value of 21.81583. In the difference in the average number of white lines of the two sexes, a significance value was obtained, namely $p = 0.000$ ($p < 0.05$ which entered the 95% confidence limit ($\alpha = 0.05$). The results of the analysis can be seen in Table 3.

Table 3. Results of analysis of differences in the average number of white lines between the sexes

Description	Sex	N	Median	Standart Deviation
	Male	230	17.5000	16.11683
	Female	230	37.0000	22.71466
	Total	460	27.0000	21.81583

Statistic Analysis (*Mann-Whitney U test*)	Average of *White Lines*
Mann-Whitney U	13059.000
Wilcoxon W	39624.000
Z Score	-9.395
Asymp. Sig (2-tailed)	0.000

The results of the statistical analysis stated that the results of the data were in accordance with research conducted by Badawi, et al., (2006) which stated that women have more white lines than men.

These results are also in accordance with research conducted by Taduran, et al., 2015 which stated that in a population in the Philippines with a sample of 400 with a total of 200 men and women each, stated that the number of white lines in women is higher compared to men. In his research, it stated that comparison of the number of white lines in men and women in the Philippines with other populations was impossible because there were no other studies published apart from the study conducted by Badawi, et al., (2006) which determined that the number of white lines as significant features for purposes of personal identification in sexual determination.

The forensic examination states that asymmetry in the human body such as the face, teeth, skull, fingerprint patterns, weight and mass of the upper and lower limbs as well as in other bones in the body (Kanchan, et al., 2008). However, there is still little about the role of asymmetry in fingerprint features. A significant difference was observed between the right and left digits in a study conducted by Taura, et al., (2020), which stated that the number of white lines on the left digit was greater than that on the right. In a study conducted on the Caucasian population of Spain, it was shown that the left hand has a smoother protrusion than the right hand and the density of the ridge is greater in the left hand area (Gutierrez, et al., 2007).

FWLC is used as a ridge-related feature found more in women than men because it has smoother protrusions and produces more numbers (Adamu et al., 2018). This means that the more epidermal ridges there are, the more frequently ridge associated white lines.

In the results of the study according to Taura, et al., (2020) stated that the results of FWLC on the left hand were more than on the right hand, in previous studies it was known that men who have higher circulating testosterone have smoother protrusions on the hands their left compared to their right hand (Jamison, et al., 1993). Also in men who have higher masculinity, have a number of protrusions on their left hand compared to their right hand (Dane, 2009).

In addition, it is also known that women have far more estrogen receptors on the skin than men which is caused by decreased estrogen levels caused by menopause which can worsen skin quality (Parage, et al., 2013), as shown by the number of lines more white (Vieira, et al., 2016).

Research conducted by Taura et al., (2006) also stated that the number of white lines in males and females had significant differences between fingerprints on the right and left fingers. White line counts performed on the Hausa population in Kano, Nigeria suggest that the FWLC asymmetry indicates that the sexual determination and predictive potential of right and left fingerprints is good. This study shows that the index and ring fingers show the highest predictive potential for men and women.

The results indicated that female FWLC was significantly higher in the left digits compared to the right digits. So that the results of this study must be inclusive when using FWLC as a sex determination (Taura, et al., 2006).

In a population in Hausa, Nigeria height or bone records may be incorrect or invalid when there is a statistically significant asymmetry between left and right sides. So notes such as left and right limbs must be precise whether using the habit of using the right hand or the left (left-handed) (Lazenby, 1994). Therefore, supporting data is needed for determining left or right as a prerequisite in determining sex with FWLC, especially among those who show left asymmetry in FWLC.

In anthropology and forensic science, the subject matter of bilateral asymmetry should be well applied and future studies should emphasize this important aspect and consider its overall effect (Krishan and Kanchan, 2016).

In identifying fingerprints, the calculation of the density of the fingerprint grooves is one of the methods for determining gender. In the research conducted by Jantz and Owsley which stated that there were significant differences between the two areas because they came from developmental instructions (Jantz and Owsley, 1977).

Population-based comparisons showing the absence of white lines fingerprints are an indication of male gender in different ethnic groups (Gasparov and Pshenichinkova, 1989). The frequency determined to infer sex varies so it is influenced by genetic influences on the white lines fingerprint. This shows that apart from determining gender, fingerprint white lines counts can be an important tool in determining an ethnic group, so further research is needed to uncover the possible role of genetics in the formation of fingerprint white lines.

Although the results of fingerprint white lines counts are promising in terms of gender interference, previous research has shown that this feature of white lines increases in frequency with age and also has significant changes in body subcutaneous fat (Ashbaugh, 1999), so it needs further study. regarding the factors that can affect fingerprint white lines counts.

The results of the study according to Vieira Silva, et al., (2016) showed that there was a significant increase in the number of white lines in the elderly group. If this is the case, then the stability of the fingerprint white lines count as a forensic tool needs to be at stake. Aging can reduce skin moisture, oil, vascularity and cause replacement of elastin protein so that cumulatively, changes that occur due to aging will reduce the elasticity of tissues and cause lesions and spots to appear due to repair of mitochondrial DNA and nuclei in the mechanism of interference in the aging process (Makrantonaki and Zouboulis, 2007).

However, changes to fingerprint features will not change the uniqueness and consistency of fingerprints. Also, women tend to have more fat than men, so this might support the hypothesis between fingerprint white lines counts and subcutaneous fat.

According to Sanchez-Andres, (2018) that age can affect changes in fingerprint grooves. In his research, it was stated that the increasing age, the less the number of fingerprint groove density. This can be caused by increasing age, the width of the skin surface.

In the context of forensic science, this research can be useful because fingerprint white lines counts in determining gender for sex inference in conditions such as natural disasters, homicide mutilations, aviation disasters where other body parts that can identify the sex of mutilation victims are out of identification.

Based on existing results and according to previous studies, it is necessary to carry out further research to find out the factors that may influence FWLC as a personal identification tool in determining sex. Factors that influence such as habits.

5. CONCLUSIONS AND SUGGESTIONS

Based on the studies that have been done, it can be concluded that there are significant differences in the number of white lines between the two sexes, namely men and women in people in Yogyakarta.

Fingerprint white lines counts have been found to be a tool in determining gender among people in Yogyakarta. Women have a significantly higher average number of fingerprint white lines than men. However, it is necessary to carry out further studies related to the use of FWLC in forensic identification tools in determining fingerprints on factors that may influence the formation ofwhite lines, such as factors from race, weight/obesity, to genetic disorders in each individual which can affect the number white lines as sex determination in forensics. Because decision making regarding individual identification is crucial, it is necessary to pay attention to the existing confounding factors.

THANK-YOU NOTE

The author would like to thank DITRESKRIMUM, INAFIS Division of the Yogyakarta Police Identification Unit, which has assisted in the process of supervising data analysis in this study.

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