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Research Article

Anthropometric Comparison of Cross-Sectional External Ear between Monozygotic Twin

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Abstract

Anthropologists are commonly believed that characteristics and the shapes of the human external ear are extensively different. The objective of this study is to explore the potential of anthropometric data from external ear in individualization of monozygotic twin which also known as identical twin. Data of external ear features using 16 landmarks along with the measurements of inter-landmark length were taken from 95 pairs of identical twins ages between 7 to 31 years old throughout Malaysia, in order to explore whether data from external ear can be used as a purpose of individualization of monozygotic twin. Measurements were taken using digital caliper with the resolution 0.01mm. Statistical analysis of all inter-landmark measurements of ear pattern conducted by multivariate analysis of variance (MANOVA) test using SPSS software to obtain the differences between both individual from the same pair of twin. Results showed that mean differences of measurement of outer ear landmarks between pairs of identical twins was only between 2.87% to 18.06%. There were no significant differences between ears of monozygotic twins for almost all dimensions of inter-landmarks and also between pair of identical twin. Among 95 pairs of monozygotic twins, only 4 pairs showed significant differences of ear pattern between their twin pairs.

ABBREVIATIONS

DNA: Deoxyribonucleic acid; **STR:** Short Tandem Repeat; **SPSS:** Statistical Package for Social or Science; **MANOVA:** Multivariate analysis of variance.

INTRODUCTION

One of the fundamental aspects of legal and in forensic is in human identification or individualization. In identifying a person, their individuality has to be established, by determining the features or set of qualities that distinguishes them from all others [1]. Forensic anthropology is one of the sub disciplines in forensic biology which usually applied in identification of human remains or body measurement for use in anthropological classification and comparison which also known as anthropometric study.

In science of identification, Bertillon system has been introduced that uses various parts of body measurement which the size remains constant throughout the life after attaining its full growth, such as head, finger, and ear [2]. Alphonse Bertillon was probably the first scientist to discover ear as a mean of identification and stated that every part of the human anatomy, including ear, was so unique that any individual could be identified if that the part of the body was properly measured and compared [3]. Since then, there are many techniques that have been introduced for human identification ranging from Bertillon system to fingerprint and DNA analysis. As the fingerprint pattern, the human external ear characteristics are unique to an individual [4]. DNA which is the genetic makeup of an individual also gives a good forensic individualization of a person from the short tandem repeat (STR) profiling, except for identical twins. Monozygotic twins which also known as identical twins which derived from the same zygote (monozygote) have the same genetic makeup and they have almost exactly the same DNA profile, so their characteristics that are determined by genetic may be similar. Fingerprints have been reported to be unique to all people including the identical twins [5]. Fingerprint is considered as physical characteristic or phenotype that is determined by the interaction of an individual's genes and the development environment in the uterus [6].

There are many benefits of using the ear as a data source for human identification. The ear has a rich structure of characteristic ear parts .The location of these characteristic elements, their direction, angles, size and relation within the ear are distinct and unique to humans, and therefore, can be used as a modality for human identification [7,8]. In recent years, some scientists have suggested that the external ear characteristics could be used to identify people with the same degree of certainty as the positive identification from fingerprints.

Human external ear which also known as auricle, has various applications in forensic science in which ear comprise a valuable identification features for identifying corpses, identifying individuals based on photographs and also for a variety of appearance reconstruction method. Recently, it is an undeniable fact in both forensic scientists and among medical circles (anatomists and anthropologists) that the structure and features of an external ear enables identification [9]. Generally, anthropologist suggested that the shapes and characteristics of human external ear are extensively different and distinguishable, in which it is probable to differentiate between individuals [10]. Even though the potential exists for the identification of human based on measurement of characteristics and observational features of the human ear, this potential has yet to be totally explored scientifically.

Apart from external ear pattern, ear print has also been used in forensic science. To claim that ear print is unique to an ear, the print must be establish that it resembles other prints from the same ear more than it resembles prints from another ear. Measurement and comparison of features and inter-individual variation of ear must be analyzed to individualize human. In a case of monozygotic twins that has the same genetic makeup, knowledge about variation between ears of identical twins has a great importance and must be consider in order to analyze whether ears of identical twins also can be consider as a tool for human identification.

MATERIALS AND METHODS

Respondents

This project has been approved by UiTM's Ethic Committee with ethical approval number *600-RMI (5/1/6/01)*. Permission for sampling at primary and secondary schools has been approved by Education Planning and Research Department (EPRD), Ministry of Education, Malaysia. All respondents were informed about all procedures and consent was obtainded from each individual. Consent from parents was obtained for students especially from primary school. Total respondents participated in this study were 95 pairs of identical twins, in which 44 pairs were male and 51 pairs were female. Respondents with previous history of craniofacial trauma, ear diseases, congenital anomalies or sugery were excluded.

Collection of data

The ear pattern data were collected from each respondent. All the samples were also subjected to morphology features analysis and parameters such as types of ear (short and broad, short and narrow, long and narrow, long and broad) and type of earlobe (attached, free). Ears were sub-classified into types based on observation and these parameters; short type of ear usually had length less than 55 mm and for ear width more than 30 mm, it was considered as broad type of ear. The descriptions for various parts of the external ear were observed and recorded. The left and right ear were also photographed using DSLR camera, NIKON D3100, lens VR, NIKON DX (AF-S NIKKOR 18-55mm 1:3.5-5.6G) and each sample was recorded with a reference number for further references of ear morphology.

Anthropometric measurement

All the samples were subjected to anthropometry analysis by determine the landmarks of the ear. 16 landmarks were used as the important features and inter-landmark length measurements were then collected based on (Figure 1).

1 to 2: Ear Length

3 to 4: Ear Width

5 to 6: Ear Base Length

7 to 8: Tragus Length

9: Tragus Height

10 to 11 : Conchal Length

12 to 13 : Conchal Width

9 to 14 : Conchal Depth

11 to 2 : Lobular Length

15 to 16 : Lobular Width

Data analysis

Simple descriptive statistics (percentage differences) of ear landmarks between twins were computed between monozygotic twins and were analyzed using Microsoft Excel.

Percentage differences = Abs (A-B)/ Max (A,B)*100

Statistical analysis was performed using IBM Statistical Package for Social or Science (SPSS) STATISTIC Version 21. Measurements of ear landmarks were taken from right and left ear of each twin and overall data from 95 pairs of monozygotic twins were analyzed using paired sample t-test. Data of inter-landmarks measurements were also compared between both individual of twin pairs and the differences were analyzed using multivariate analysis of variance (MANOVA). P-value ($p<0.05$) were considered to be statistically significant difference.

RESULTS AND DISCUSSION

Classification of general features of external ear

General observations were done on the type and shape of

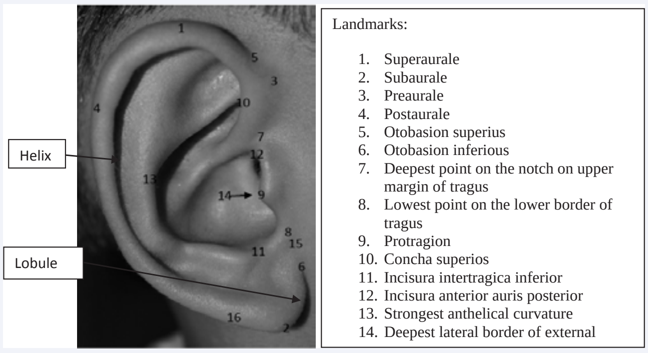

Figure 1 Reference points of inter-landmark measurement used for anthropometric measurements [10].

ears and also the type of earlobe, prior to detail measurement of the outer ear inter-landmark. Ear type and shape for both individual from the same pair were compared to identify pairs with a similar or different ear pattern. There were four sub-classifications of ear types studied which was long and broad, long and narrow, short and broad and short and narrow types (Figure 2). According to Dhanda et al., [11] there were four basic shape of human ear which were oval, rectangular, round and triangular. For this study, apart from oval, rectangular, round, and triangular, we have discovered new shape of human ear which were rectoval and trioval. Rectoval as in Figure 3e was a combination of rectangular with oval shape. In addition, Trioval (Figure 3 (f)) was a combination of two basic shapes which were triangular and oval shapes. There were two types of earlobe discovered in this study which were attached and free as showed in (Figure 4).

Identification of 16 landmarks was done prior to measuring the inter-landmarks directly on the respondents' ears. The anthropometric data which include 95 pairs of identical twins were represented in Table 1. Based on three main features studied, most of respondents have similar types, shapes and type of earlobe with their pairs, with percentage of 62.11%, 68.43%, and 83.16% respectively.

As in (Table 1), from types of ear of all respondents studied, 59 pairs (62.11%) of identical twins have the same ear type with their twins while other 36 pairs (37.9%) were differed between pairs. Twins that possessed the same shape of ear with their pairs were also higher in number. Oval shape was the highest recorded which was 43.16% from overall identical twins. Rectoval and trioval shapes were the least found, obtained from only 5% of the total respondents. Most of twin pairs have same type of earlobe (83.16%) and while only 16.84% differed to their pair.

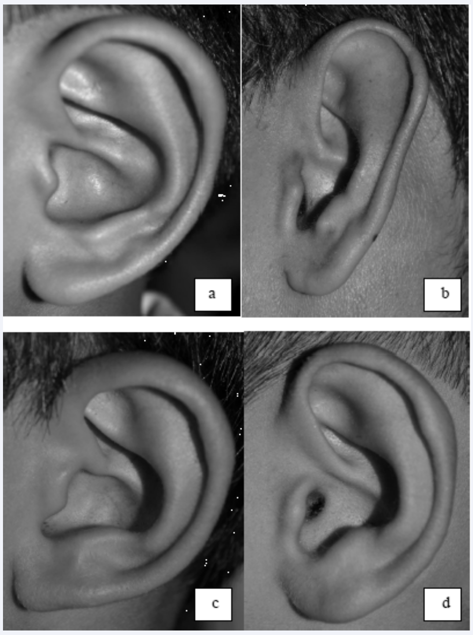

Figure 2 Type of human ear, (a) Long and Broad; (b) Long and Narrow; (c) Short and Broad; (d) Short and Narrow.

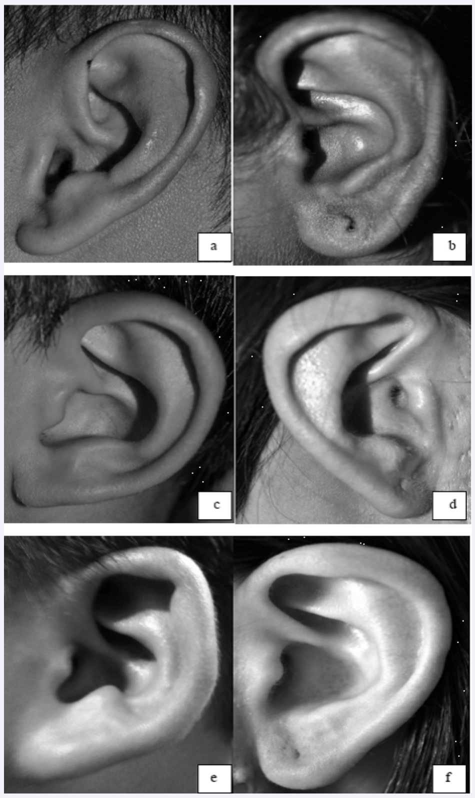

Figure 3 Shape of human ear, (a) Oval; (b) Rectangular; (c) Round; (d) Triangular; (e) Rectoval; (f) Trioval.

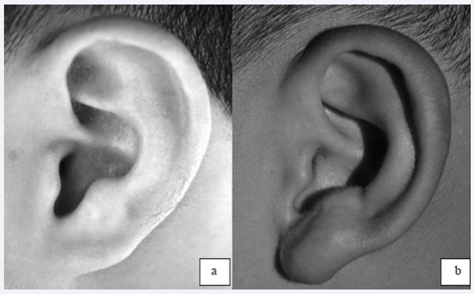

Figure 4 Type of human earlobe, (a) Attached; (b) Free.

Anthropometric measurements of inter-landmarks between pairs

Ear dimensions were measured using 16 landmarks on ear for inter-landmark measurement. Descriptive statistics of ear dimension of inter-landmarks in (Table 2) presented that there is no obvious differences between ears of identical twins. The differences between twin pairs were very low and it produced low percentage of differences for all measurements between ears of identical twins which was only 2.87% to 18.06%.

Apart from descriptive statistics, all inter-landmarks of 95 pairs of monozygotic twin data were analyzed by statistical analysis by using IBM SPSS version 21 Software. From analysis of paired samples t-test between 95 pairs of identical twins, result showed that there were no significant differences between ears of

Table 1: Frequency (%) of monozygotic twins with general external ear features classified accordingly to the morphological of their ears.

Features	Classification	Sub-Classification	No. of Pairs (%)
Type Of Ear (Size)	Same Between Pair	Long & Broad	22.11
		Long & Narrow	18.95
		Short & Broad	-
		Short & Narrow	16.84
		Long & Broad/ Long & Narrow	3.16
		Long & Broad/ Short & Broad	1.05
	Differ Between Pair	Long & Broad/Short & Broad	3.16
		Long & Broad/Long & Narrow	17.89
		Short & Broad/ Short & Narrow	8.42
		Long & Narrow/Short & Narrow	2.11
		Long & Broad/Short & Broad/ Short & Narrow	2.11
		Long & Narrow/Short & Narrow/ Short & Broad	2.11
		Long & Broad/Long & Narrow/ Short & Broad	1.05
		Long & Broad/Long & Narrow/ Short & Narrow	1.05
Shape Of Ear	Same Between Pair	Oval	43.16
		Rectangular	10.53
		Round	1.05
		Triangular	2.11
		Rectoval	2.11
		Oval/ Round	2.11
		Rectangular/ Round	1.05
		Oval/Rectangular	5.26
		Oval/Triangular	1.05
	Differ Between Pair	Oval/Round	5.26
		Oval/Rectangular	17.89
		Oval/Triangular	2.11
		Oval/Trioval	1.05
		Round/ Rectangular	1.05
		Oval/Triangular/ Rectangular	1.05
		Oval/Rectangular/ Rectoval	1.05
		Oval/Round/Rectangular	1.05
		Oval/Rectoval	1.05
Type Of Earlobe	Same Between Pair	Free	34.74
		Attached	44.21
		Free/ Attached	4.21
	Differ Between Pair	Free/ Attached	16.84

Table 2: Descriptive statistics of inter-landmarks length differences between 95 pairs of monozygotic twins.

Dimension	Ear Position	Average Differences Between Pairs (mm)	Average Percentage Differences (%)	p-Value
Ear Inclination Angle	Left Ear	1.52	15.61	0.417
	Right Ear	1.57	15.89	0.376
Ear Length	Left Ear	1.72	2.97	0.109
	Right Ear	1.69	2.87	0.756
Ear Width	Left Ear	1.50	4.67	0.534
	Right Ear	1.75	5.44	0.021
Ear Base Length	Left Ear	2.42	5.58	0.003
	Right Ear	2.32	5.38	0.407
Tragus Length	Left Ear	1.49	7.43	0.940
	Right Ear	1.19	6.33	0.861
Tragus Height	Left Ear	0.86	18.06	0.449
	Right Ear	0.77	14.39	0.636
Conchal Length	Left Ear	1.30	4.83	0.286
	Right Ear	1.20	4.47	0.144
Conchal Depth	Left Ear	1.71	9.59	0.637
	Right Ear	1.60	8.82	0.889
Conchal Width	Left Ear	1.41	7.55	0.260
	Right Ear	1.31	7.03	0.513
Lobular Width	Left Ear	1.17	6.69	0.991
	Right Ear	0.93	5.31	0.852
Lobular Length	Left Ear	1.56	8.58	0.080
	Right Ear	1.60	8.75	0.783
Protrusion At Superaurale	Left Ear	1.83	15.77	0.164
Level	Right Ear	1.72	16.74	0.315
Protrusion At Tragal Level	Left Ear	1.99	10.9	0.453
	Right Ear	2.32	12.88	0.276

monozygotic twins for almost all dimensions of inter-landmarks except for ear base length of left ear ($p = 0.003$).

Multivariate analysis of variance (MANOVA) was also conducted to see whether there is a significant difference between ear patterns between each twin pairs of monozygotic twins. Based on (Table 3), percent of significant differences of each inter-landmarks length were very low among monozygotic twins. Less than 12% of monozygotic twins were differed significantly between their twin pairs and the highest difference was only found in tragus length (11.6%). Tragus height data showed that no pair was significantly different between their pairs for this type of dimension. According to the values and based upon the standard α of .05, monozygotic twins in all independent-variable categories do not have significantly different characters or pattern when $p > 0.05$. They do, however, have significantly different when $p < 0.05$. Results from overall MANOVA analysis showed that there were no significant differences found between

Table 3: Percent (%) differences of each inter-landmarks length between 95 pairs of monozygotic twins.

Dimension	No. of Pairs With p <0.05	Percentage Significant Differences Between Pairs (%)
Ear Inclination Angle	5	5.3
Ear Length	5	5.3
Ear Width	2	2.1
Ear Base Length	6	6.3
Tragus Length	11	11.6
Tragus Height	0	0
Conchal Length	10	10.5
Conchal Depth	9	9.5
Conchal Width	6	6.3
Lobular Width	6	6.3
Lobular Length	8	8.4
Protrusion At Superaurale Level	4	4.2
Protrusion At Tragal Level	8	8.4

ears of 95 pairs monozygotic twins except for only 4 pairs that showed significant differences ($p<0.05$) of ear pattern between their pairs. From analysis, 4 pairs that have the F of 259.155 and the p of 0.044, ($F= 11889.895$, $p= 0.006$), ($F=29861.279$, $p= 0.004$) and ($F=2306411.68$, $p= 0.000$) indicate a significant difference between the mean of all inter-landmark length. Based on Figure 5, it showed that majority (95.8%) ears of monozygotic twins have no significant differences between their twin pairs and it revealed that there is an exception for ear of monozygotic twins to be used in individualization of human.

External ear has been applied in forensic investigation in few countries and quantitative data has been obtained in several human populations such as Italian, American and British Caucasians, African and Han population, Korean, Japanese and also Indians [12]. Therefore, the proposed study is important as additional information on Malaysian population for reference databases to the existing data on other ethnic groups.

Currently, personal identification using ear images has been increasingly studied because the ear is useful for personal biometric. It is primarily due to its stable structure that is preserved since birth and being rigid to the changes in facial and pose expression, and also reasonably immune from anxiety and hygiene problems with several other biometric candidates [13].

Evaluation of features differences in anthropometric measurements for monozygotic twins is important since many scientists claimed that human ear creating almost unique shapes similar to the unique fingerprint of each individual [14] without considering ears of monozygotic twins. The ears of monozygotic twins may show strong similarities since they have the same DNA structures, but there have been little efforts to investigate the human ear of monozygotic twins for personal authentication and also to be applied in forensic investigations.

From our study, we found that most of the twin pairs possessed the same external ear features based on comparison of their ear type, shape, and lobule, with their pairs. Comparison

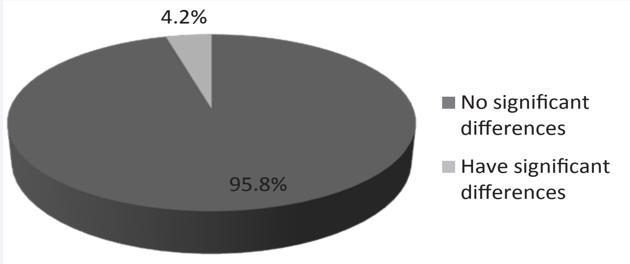

Figure 5 Percent (%) differences in anthropometric data of ear pattern between pairs of monozygotics twins.

of inter-landmark measurements also revealed the similarity of external ear landmarks between the same pairs of monozygotic twins.

Some differences in ears of monozygotic twins were found but statistically they were not significant. The discovery of similarity in external ear of monozygotic twins was against the report by Purkait & Singh [10] that emphasizing on the high differences of ear pattern in all human population. This novel finding of monozygotic twins suggested due to the similarity of their genetic makeup since they basically have same DNA profile. Monozygotic twins derived from only one zygote and it resulted in same physical characteristics between pairs of the twin. Data collected in this research could be a preliminary database for the quantitative analysis and description of normal human external ear for monozygotic twins and would initiate further analysis of ear between monozygotic twins in a broad range.

Exploration on the potential of ear pattern as an alternative or additional forensic discrimination tool, especially between monozygotic twins has been started by Meijerman et al., [15]. He demonstrated differences in ear print of six monozygotic twin pairs and suggested the potential of ear print in individualizing monozygotic twins just like fingerprint**.** However from our study on the general ear features of ear pattern of a larger group of monozygotic twins, which were 95 pairs of monozygotic twins, we found that ear pattern has less potential to be applied for this purpose.

CONCLUSION

In conclusion, based on this result, it was found that external ear of monozygotic twins cannot be compared easily since they have strong similarity in relation to their same genetic makeup. It is believed that the result obtained in this study would serve some useful purposes in ear morphology and for anthropometric considerations among Malaysian.

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