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ANTHROPOMETRIC INVESTIGATION OF EXTERNAL EAR MORPHOLOGY, AS A PATTERN OF UNIQUENESS, USEFUL IN IDENTIFYING THE PERSON

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The auricle plays an important role in clinical diagnosis, in facial aesthetics or artificial prosthesis. Recent studies have focused on using ear pattern in person identification. Anthropometric data of the ear shows the difference by gender, age, ethnicity and geographical region. Over time, studies have been conducted on different populations. The current study attempted to provide a correct and reproducible protocol for identifying anthropometric features and measuring biometric parameters of ear. Firstly analysis of errors in determining anthropometric landmarks was performed (inter and intra-observer tests). In the next step possible differences between the right and left ear (distances, angles and indexes) were assesed. Subsequently, in order to study the uniqueness of ear pattern, the existing correlations within the same ear were analyzed. The aim of this pilot study conducted on a small number of subjects, is to opening up the perspectives of an extended study to a representative sample of the Romanian population. The study was conducted on 14 subjects recruited from the students of the Faculty of Biology, University of Bucharest. The results of the present study confirm the hypothesys that every single ear is unique and may be used for personal identification.

Keywords: external ear morphology, biometry, person identification, uniqueness.

INTRODUCTION

The ear is known especially as an organ of the auditory sense. However, the external region of the ear, the pinna, apart from the role of capturing the sound waves, may have scientific interest from other points of view.

The auricle plays an important role in the clinical diagnosis of congenital anomalies and syndromes[1]. Thus, Marfan syndrome or Fragile X syndrome is associated with macrotia and large ear[2]; Down's syndrome patients have smaller auricles than normal; trisomy 13, trisomy 18[3] or anencephaly are characterized by the presence of displastic ears[4].

Morphological features of the external ear are important for facial aesthetics. Any anomaly in size, shape, spatial position, symmetry, even the lack of auricular regions can be corrected today by aesthetic surgery.

Manufacturer needs the ear pinna dimmensions for making low cost ear artificial prosthesis, very useful in maxillofacial rehabilitation[5].

Recently, studies have focused on the use of information in the field of person identification, the external ear being a useful tool in biometrics[6].

Although aesthetic surgery and forensics are interested in the morphology, growth and development of the ear, few studies have been devoted to its anthropological study.

Anthropometric data of the ear shows the difference by gender, age, ethnicity, geographical region. Over time, studies have been conducted on different populations: West German and Nord American whites[7], Turkish[8-10], Italian[11], Spanish[12, 13], Indian people[1, 14, 15].

Up to date, very few studies on auricular dimensions have been reported from Romania[16]. For this reason we consider that new extensive studies of somatometry and somatoscopy of the external ear are necessary in this region.

The current study attempted to provide a correct and reproducible protocol for identifying anthro-

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pometric features and measuring biometric parameters of ear. The aim of this pilot study conducted on a small number of subjects, is to opening up the perspectives of an extended study to a representative sample of the Romanian population.

MATERIALS AND METHODS

PARTICIPANTS

The study was conducted on 14 subjects recruited from the students of the Faculty of Biology, University of Bucharest, aged between 20 and 25 (mean age = 22 ± 1.164). After being informed in detail about the study, subjects who declared themselves volunteers signed an informed consent, agreeing that photographs and data from their processing to be used in the research. Confidentiality and data protection has been guaranteed and achieved by allocating to each participant a code number for identification. Healthy, genetically unrelated subjects were selected for study.

In order to obtain optimum results, certain exclusion criteria of volunteers were applied. Were not included in the study those with a history of maxillo-facial deformity, congenital abnormalities, ear trauma, malignancies, ear disorders, ear surgery.

EXPERIMENTAL PART

For the anthropometric measurements we chose the photogrammetry method, an indirect measurement method.

The subjects were seated in a chair in front of a table, with their chin supported on a custom-made height-adjustable device to guide the head in the Frankfurt Horizontal (FH) plane. They were positioned at a distance of 1.10 m in front of the camera placed on a tripod.

A rectangular scale of 60x80 mm fixed on a support was placed laterally by the ear, taking care to be tangent to the zigomatic arch (Figure 1). All participants were asked to remove their ear accessories.

It was taken into account that the vertical axis of the scale and the ear were parallel. To be able to check the head orientation, the horizontal line of the scale was arranged parallel to the HF. The focal plane of the camera was positioned parallel to the focal plane of the scale[14]. Images from both ears were acquired with BenQ AC100 digital camera with 14 Mega Pixel resolutions.

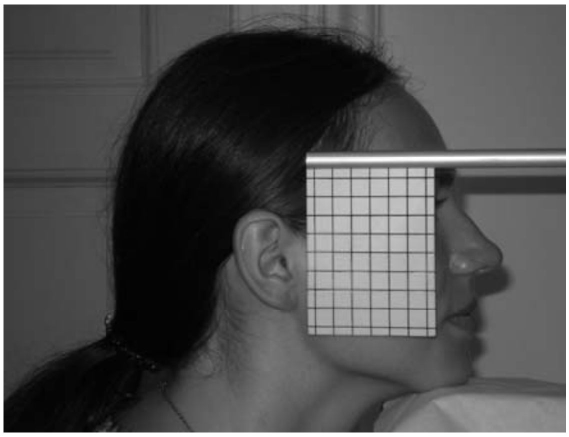

Figure 1. Head orientation in the Frankfurt Horizontal (FH) plane.

All photos were taken under the same lighting and positioning conditions. Optical zoom with 4X value was used.

The acquired images were processed using Fiji – ImageJ program[17]. For the left ear a horizontal flip was made to match the orientation of the image to that of the right ear.

There have been taking into account 14 anthropometric landmarks at the level of each of the two ears (Figure 2):

- *superaurale* (1) – the highest point on the free edge of the helix[18];
- *subaurale* (2) – the highest point on the free edge of the helix[18];
- *preaurale* (3) – the point located most front of the ear, just before the helix attachment area at the head[19];
- *postaurale* (4) - the most anterior point of the ear, located on the free edge of the helix[19];
- *concha superior* (5) – the intersection of the lower edge of the anterior end of the crus antihelicis inferius and the posterior border of crus helicus[20];
- *incisura intertragica inferior (*6) – the deepest point in the incisura intertragica[10];
- *incisura anterior auris posterior* (7) – the most posterior point on the edge of incisura anterior auris[20];
- *strongest anthelical curvature* (8) [20];
- *otobasion superior* (9) – the superior point of juncture between the ear and the head (temporal bone)[19];
- *otobasion inferior* (10) – the superior point of juncture between the ear and the chin;

- *protragion* (11) – the tip of the tragus;
- *antitragus superior* (12) – the tip of the antitragus;
- *lobule anterior* (13) – the point situated at the intersection between the line perpendicular to the physiognomic length of the ear at the midpoint of lobular length with the morphological length of the ear[21];
- *lobule posterior* (l4) – the point situated at the intersection between the line perpendicular to the physiognomic length of the ear (at the midpoint of lobular length) and the free edge of the helix[21].

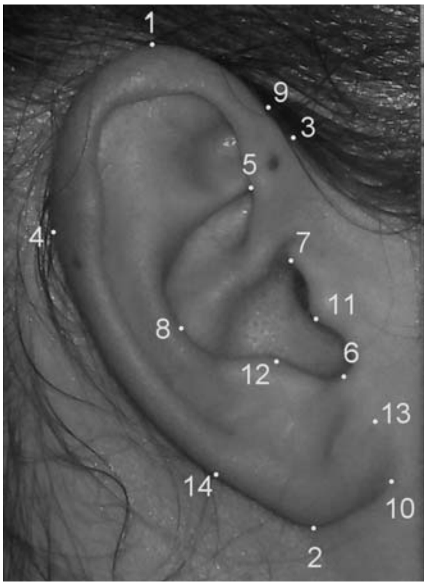

Figure 2. Landmarks of the external ear:
superaurale (1); subaurale (2); preaurale (3); postaurale (4); concha superior (5); incisura intertragica inferior (6); incisura anterior auris posterior (7); strongest anthelical curvature (8); otobasion superior (9); otobasion inferior (10); protragion (11) antitragus superior (12); lobule anterior (13); lobule posterior (14).

Eight anthropometric distances have been considered (Figure 3):

- *Auricular length* (1–2) – *physiognomic length of the ear* – straight distance between superaurale and subaurale following the longitudinal axis of the ear[21, 22]
- *Auricular width* (3–4) – *physiognomic width of the ear* straight distance between preaurale and postaurale[21, 22]
- *Lobular lenght* (2–6) straight distance between the deepest point in the incisura intertragica and subaurale[21, 22]
- *Lobular width* (13–14) straight distance between the anterior lobule and posterior lobule at the midpoint of lobular length and perpendicular to medial longitudinal axis of auricle [21, 23]
- *Conchal lenght* (5–6) – straight distance between concha superior and incisura intertragica inferior
- *Conchal width* (7–8) – straight distance between most posterior point on the edge of the incisura anterior auris and the strongest anithelical curvature[21, 22]
- *Intertragic distance* (11–12) straight distance between tragus and antitragus
- *Morphological length of the ear* (9–10) – straight distance between otobasion superior and otobasion inferior[20]

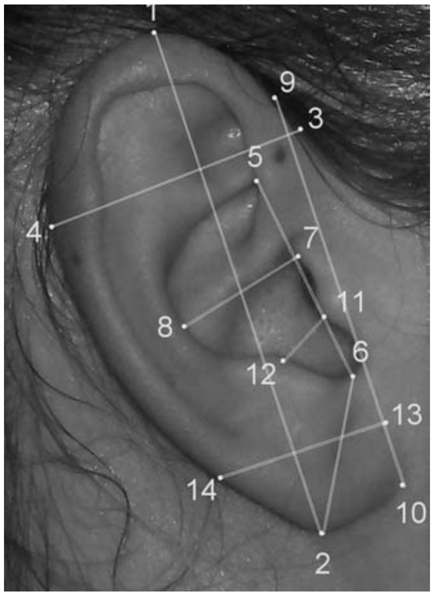

Figure 3. Distances identified at the ear.

There were calculated four angles with significance in the proportions of the ear. In our opinion these are the angles with an important connotation in the individuality of the person. (Figure 4):

- the angle between physiognomic length of the ear and the vertical (*auricular inclination angle)*;
- the angle between physiognomic length of the ear and physiognomic width of the ear*;*
- the angle between physiognomic length of the ear and lobular length*;*
- the angle between physiognomic length of the ear and morphological length of the ear.

The measurements mentioned were included into the calculation of some anthropometric indices:

- Auricular index (AI)

$$AI = \frac{width\_of\_auricle}{lenght\_of\_auricle} \times 100 \quad (1)$$

- Conchal index (CI)

$$CI = \frac{width\_of\_concha}{lenght\_of\_concha} \times 100 \quad (2)$$

- Lobular index (LI)

$$LI = \frac{lobular\_width}{lobular\_lenght} \times 100 \quad (3)$$

- Ear attachment index (AtI)

$$AtI = \frac{morpho\log ical\_length}{physiognomic\_length} \times 100 \quad (4)$$

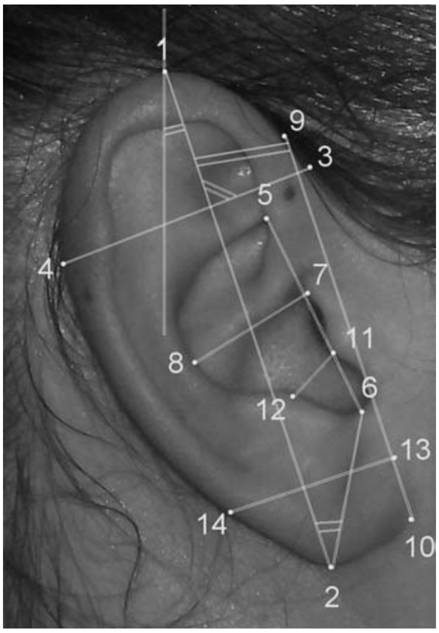

Figure 4. Important angles identified at the ear.

STATISTICAL ANALYSIS

Data processing was performed with SPSS version 19.0 (Microsoft Corperation Inc., Chicago, IL, USA). Firstly analysis of errors in determining anthropometric landmarks was performed (inter and intra-observer tests).

In the next step possible differences between the right and left ear (distances, angles and indexes) were assesed. Subsequently, in order to study the uniqueness of ear pattern, the existing correlations within the same ear were analyzed.

Simple statistical analysis (mean, standard deviation, variation coefficient, standard error) was performed on each data set. Different parameters have been searched for significant statistical correlations. A $p<0.05$ value was considered statistically significant.

Analysis of anthropometric landmarks placing errors

The special pattern of the ear, the subjectivism in establishing the position of the landmarks and the difficulties of the photogrammetric technique may induce experimental errors. The magnitude of the measurement error should be estimated and taken into account when performing the studies on the ear.

In this study we performed *ab initio* independent intra- and inter- observer tests that aimed to determine the average error that occurs when marking the location of the anthropometric landmarks.

Therefore, we sought the objectivity versus the ambiguity of a set of three anthropometric landmarks more exposed to subjectivism.

Intra-observer tests

For intra-observer studies, the same person performed landmarks placing for five different images in three sessions, 2 to 4 days apart.

There were chosen three anthropometric points considered the most susceptible to errors in position estimation: the point in the *incisura intertragica inferior* (6), *strongest anthelical curvature* (8) and *protragion* (11). The right ear was chosen. The results of the errors at each point result from the Euclidean distances between the resulting positions and the calculated mean position.

Inter-observer tests

For inter-observer studies three different people made landmarks placing for the same five different images in three sessions, 2 to 4 days apart.

The same three anthropometric points, considered the most susceptible to errors, were chosen.

The position of a point determined by an observer was chosen as the average position between the three determinations made by that observer.

Errors recorded at the position of each point result from the Euclidean distances between the positions indicated by the three observers and the resulting average position.

RESULTS AND DISCUSSION

LANDMARK ERRORS ESTIMATIONS

Prior to the actual data collection, an analysis of positioning of the anthropometric landmarks and measurement accuracy was carried out.

Thus, intra-observer (Table 1) and inter-observer (Table 2) tests were performed by which the measurement errors were calculated.

Table 1

Average error for intraobserver estimations [mm]

	Point 6		Point 8		Point 11	
	average	SD	average	SD	average	SD
Subj. 1	0.31	0.14	0.67	0.53	0.28	0.11
Subj. 2	0.15	0.02	0.38	0.17	0.13	0.09
Subj. 3	0.23	0.04	0.33	0.14	0.27	0.18
Subj. 4	0.17	0.04	0.66	0.30	0.11	0.09
Subj. 5	0.49	0.15	0.39	0.24	0.19	0.13
Total average errors	0.27	0.09	0.48	0.28	0.20	0.12

Table 2

Average error for inter-observer estimations [mm]

	Point 6		Point 8		Point 11	
	average	SD	average	SD	average	SD
Total average errors	0.30	0.28	0.60	0.54	0.28	0.28

As can be seen in Figure 5, the errors of anthropometric landmarks placement for the same observer are very small, the point located in the antihelical curve presenting the greatest difficulty in setting the parameters.

The wide curvature of the conch is responsible for the difficulty of identifying the exact position of the antropometric marker.

As can be seen in Figure 6, for the inter-observer test the average errors for placing of anthropometric landmarks are slightly higher than those in the intra-observer test and the dispersion of these errors is much larger. This is due to the fact that one of the three observers (observer 3) had a greater variability in determining the position of the antropometric. For this reason we have decided that for the entire set of measurements it is important to select a single observer, chosen from those with lower errors, and has expertise in anthropometric measurements.

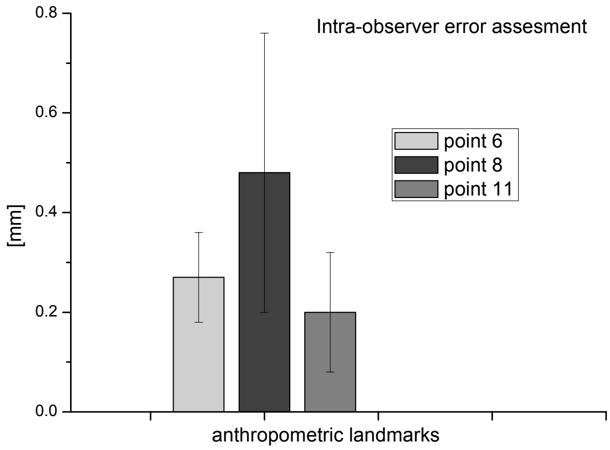

Figure 5. Intra- observer errors of anthropometric landmarks placement.

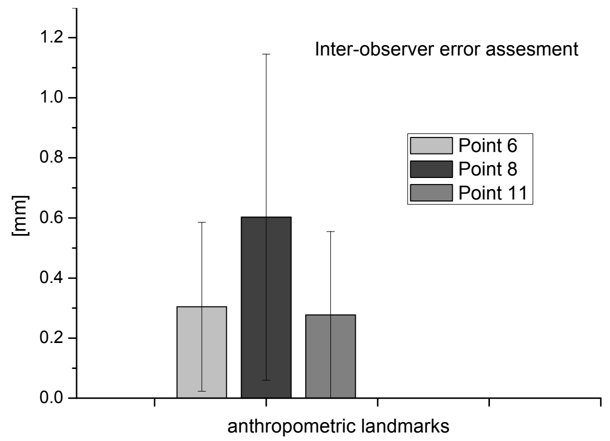

Figure 6. Inter- observer errors of anthropometric landmarks placement.

COMPARATIVE ASSESMENT BETWEEN RIGHT AND LEFT EAR

Once the degree of low error in determining the anthropometric landmarks has been established, the first batch of subjects was measured. Following the measurements, a first analysis of the recorded data was made.

Dimensional diferences between ears

The measurements and comparison of results for the right and left ears among study subjects are shown in the Table 3.

Table 3

Compartive test for dimensional parameters for the two ears

Measured parameters	Ear	Average [mm]	Min [mm]	Max [mm]	SD	SE	CV	t-test	p-value
physiognomic ear length	R	59.27	55.1	67.3	4.09	1.09	6.90	-2,375	0.034
	L	60.69	55.8	68.2	4.55	1.22	7.49		
physiognomic ear width	R	32.16	29	43.3	3.57	0.96	11.11	-0,753	0.465
	L	32.71	28.5	42.6	3.66	0.98	11.18		
lobular length	R	18.45	15.4	23.7	2.32	0.62	12.55	0.205	0.841
	L	18.58	15.5	22.7	2.34	0.63	12.62		
lobular width	R	17.04	9.3	22	3.52	0.94	20.62	-1,029	0.322
	L	17.31	8.5	23.7	3.99	1.07	23.06		
concha length	R	24.61	15.3	27.5	3.03	0.81	12.32	-1,291	0.219
	L	25.53	22.8	28.5	1.93	0.52	7.58		
concha width	R	15.04	10	18.3	2.30	0.61	15.27	0.231	0.821
	L	15.05	10.4	21.1	2.98	0.80	19.82		
intertragic distance	R	7.18	4.4	9.5	1.60	0.43	22.23	0.101	0.921
	L	7.06	3.9	9.3	1.63	0.44	23.11		
morphological ear length	R	46.78	41.4	51.4	3.14	0.84	6.71	0.432	0.673
	L	46.96	38.4	52.5	4.68	1.25	9.97		

R – right ear; L – left ear

Descriptive statistics made for the main dimensional parameters of the two ears – right / left – give us just an indicative dimensional range, taking into account that the number of individuals included in the study group is not large enough.

The main parameter indicators (mean, standard deviation – SD, standard error – SE and coefficient of variation) were evaluated.

The coefficient of variation of some measurements shows the high degree of spread of the care values comprised of the averages obtained. For values lower than 15%, this average is representative, and for values between 15 and 30% the average is sufficiently representative, the dispersion being medium.

Among the linear dimensions measured at the ear, the greatest variability is the *lobular width* and the *intertragic distance*. At the opposite pole, the *physiognomic length* and the *morphological length* of the ear are the least variable dimensional parameters.

With a few exceptions, we can see greater variability of left ear parameters. Also, the linear dimensions of the left ear are slightly larger than those of the right ear.

To compare the dimensional values between the two right / left ears, t test ("pair t test") was applied. We started from the hypothesis that the two ears of the same person are different. The hypothesis supports the dimensional asymmetry of the ears, as well as the justification of the preponderant choice of one of the ears for biometric identification of the person (the specific pattern of the every ear).

The number of degrees of freedom of the test is 13 (df = N-1). We set $\alpha = 0.05$. The critical value t is 2.160.

Analyzing the Table 3, for $p < 0.05$ we can see that the hypothesis from which we started is confirmed only for the physiological length of the ear. The negative sign of t indicates that the left ear is longer than the right ear.

For the other parameters there is no significant statistical difference between ears.

Angles diferences between ears

Further dimensional parameters of the ear, such as the angle between different anthropometric segments, were also analyzed. Table 4 shows the angles diferences between the right and left ear.

Table 4

Angles diferences between the right and left ear

angle between	Ear	Average	SD	CV	t-test	p-value
ear length/the vertical	R	16.83	8.90	51.67	0.497	0.635
	L	16.39	9.95	66.83		
ear width/ length	R	73.45	7.37	10.44	-0.440	0.667
	L	74.30	7.71	11.26		
lobular length / ear length	R	24.70	10.23	43.37	1.315	0.211
	L	22.14	13.38	61.98		
morpholo-gical length / ear length	R	4.24	5.83	151.13	-0.887	0.391
	L	5.04	6.06	124.92		

R – right ear; L – left ear

It is noticed that angles represent the category of parameters with the highest degree of variability among subjects. Moreover, the angle with the greatest variability in the population is the angle between the physiognomic length and the morphological length of the ear.

Indexes diferences between ears

Another analysis performed was related to anthropometric indexes (Table 5).

Table 5

Index diferences between the right and left ear

	Ear	Average	SD	CV	t-test	p-value
Auricular index (AI)	R	54.40	5.77	10.61	0.450	0.660
	L	53.93	4.54	8.42		
Ear attachment index (AtI)	R	78.40	7.18	9.16	1.449	0.171
	L	75.77	8.46	11.16		
Conchal index (CI)	R	62.05	12.45	20.07	0.915	0.377
	L	59.05	11.00	18.64		
Lobular index (LI)	R	92.59	17.48	18.8	-0.467	0.648
	L	93.56	20.67	22.09		

R – right ear; L – left ear

From the point of view of variability, Table 5 shows a greater dispersion of the values for the conchal and lobular indexes, which shows a greater variability of the forms in these regions.

It can be noticed that in case of angles and indexes, there is no significant statistical difference between the two ears.

EVALUATING THE DEGREE OF UNIQUENESS OF THE EAR PATTERN

The shape of the ear is mainly determined by the proportions of its different dimensions, less than their absolute values.

Two ears differ if there is no correlation (strong correlation) between their dimensions.

In order to verify the degree of morphological individuality we evaluated the existing correlations between the dimensional parameters for the whole set of subjects. The lesser the correlations are and the larger the proportions between dimensions, the more morphologically different the ears.

Parameters least related to others may be considered if the person is to be identified.

For this reason, in this study we made the calculation of the Pearson correlation coefficient between all pairs of dimensional parameters for each individual ear.

Table 6 presents the correlations for the right ear of the subjects under study, and in Table 7 the correlations for their left ear are represented.

Analyzing the values in these tables, it is noted that of the 28 possible correlations between dimensional parameters of the ear only 3 in the right ear and 4 in the left ear are significant. This observation confirms the hypothesis that the ears differed morphologically between the analyzed subjects, being an argument in favor of demonstrating the uniqueness of the ear at the level of the individuals.

The existence of a lower number of correlations in the right ear recommends it for use in the procedures for person identification

Ear width, lobe height, concave length, and morphological length of the ear are the most independent parameters, so they can be considered first in identification procedures.

The results presented in this paper are strictly indicative, as the number of subjects included in the study is not enought for a statistically significant sample. However, the milestones were set for starting a more extensive anthropological research in order to determine the morphological and dimensional characteristics of the external ear for the Romanian population.

Table 6

Pearson correlation between dimensional parameters for the right ear

		ear length	ear width	lobular length	lobular width	concha length	concha width	intertragic distance	morphologic ear length
ear length	Pearson Correlation	1	0.309	0.559*	0.397	0.399	0.395	0.045	0.181
	Sig. (2-tailed)		0.283	0.038	0.160	0.158	0.162	0.880	0.536
ear width	Pearson Correlation	0.309	1	-0.332	-0.044	0.391	0.431	-0.097	0.019
	Sig. (2-tailed)	0.283		0.246	0.881	0.167	0.124	0.741	0.948
lobular length	Pearson Correlation	0.559*	-0.332	1	0.510	0.017	-0.139	-0.277	0.032
	Sig. (2-tailed)	0.038	0.246		0.062	0.953	0.636	0.337	0.915
lobular width	Pearson Correlation	0.397	-0.044	0.510	1	0.122	0.538*	0.426	-0.450
	Sig. (2-tailed)	0.160	0.881	0.062		0.679	0.047	0.129	0.106
concha length	Pearson Correlation	0.399	0.391	0.017	0.122	1	0.241	-0.020	-0.149
	Sig. (2-tailed)	0.158	0.167	0.953	0.679		0.407	0.946	0.612
concha width	Pearson Correlation	0.395	0.431	-0.139	0.538*	0.241	1	0.723**	-0.400
	Sig. (2-tailed)	0.162	0.124	0.636	0.047	0.407		0.003	0.157
intertragic distance	Pearson Correlation	0.045	-0.097	-0.277	0.426	-0.020	0.723**	1	-0.308
	Sig. (2-tailed)	0.880	0.741	0.337	0.129	0.946	0.003		0.285
morphologic ear length	Pearson Correlation	0.181	0.019	0.032	-0.450	-0.149	-0.400	-0.308	1
	Sig. (2-tailed)	0.536	0.948	0.0915	0.106	0.612	0.157	0.285	

Table 7

Pearson correlation between dimensional parameters for the left ear

		ear length	ear width	lobular length	lobular width	concha length	concha width	intertragic distance	morphologic ear length
ear length	Pearson Correlation	1	0.498	0.036	0.126	0.802**	0.432	0.393	0.233
	Sig. (2-tailed)		0.070	0.902	0.669	0.001	0.123	0.165	0.424
ear width	Pearson Correlation	0.498	1	-0.399	-0.030	0.485	0.692**	0.327	0.022
	Sig. (2-tailed)	0.070		0.158	0.918	0.079	0.006	0.254	0.941
lobular length	Pearson Correlation	0.036	-0.399	1	0.327	-0.051	-0.359	-0.217	0.066
	Sig. (2-tailed)	0.902	0.158		0.255	0.863	0.207	0.455	0.821
lobular width	Pearson Correlation	0.126	-0.030	0.327	1	-0.217	0.383	0.562*	-0.529
	Sig. (2-tailed)	0.669	0.918	0.255		0.456	0.176	0.036	0.052
concha length	Pearson Correlation	0.802**	0.485	-0.051	-0.217	1	0.277	0.258	0.371
	Sig. (2-tailed)	0.001	0.079	0.863	0.456		0.337	0.374	0.191

Table 7 (continued)

concha width	Pearson Correlation	0.432	0.692**	-0.359	0.383	0.277	1	0.720**	-0.098
	Sig. (2-tailed)	0.123	0.006	0.207	0.176	0.337		0.004	0.740
intertragic distance	Pearson Correlation	0.393	0.327	-0.217	0.562*	0.258	0.720**	1	-0.307
	Sig. (2-tailed)	0.165	0.254	0.455	0.036	0.374	0.004		0.285
morphologicear length	Pearson Correlation	0.233	0.022	0.066	-0.529	0.371	-0.098	-0.307	1
	Sig. (2-tailed)	0.424	0.941	0.821	0.052	0.191	0.740	0.285	

Thus, an experimental positioning device, necessary for head orientation in the Frankfurt Horizontal plane was made. At the same time, a graduated scale and a gripping and fastening support were made to establish the dimensional standard of the photographic image. The parameters required to obtain a clear and accurate photo (the use of a tripod to fix the camera, the optimal shooting distance, the optical zoom used, the way to illuminate the subjects) have been set.

Limitations of the study are given primarily by the small number of subjects in the batch, then by the lack of a balanced gender distribution. Also, only one age category of the population was included in the study.

CONCLUSIONS

The research presented in this paper is strictly indicative, the main purpose being to establish a working protocol useful in determination of human ear dimensions related to the uniqueness of its morphological pattern. As we stated, there are few anthropological ear-related studies in Romania. For this reason we consider that new extensive studies of the external ear are necessary in this region.

Although seemingly easy to achieve, actually measuring the dimensions of the ear auricle raises a number of technical and procedural issues both in terms of image acquisition and related to the correct identification of anthropometric features.

For this reason, before we started collecting data from an extended group of subjects, we limited to a small sample (14 students). The same age category (20-30 years) was chosen to maintain similar characteristics of the study group. However, gender distribution was not taken into account, since we are talking only of a male individual.

The results of the present study confirm the hypothesys that every single ear is unique and may be used for personal identification.

Among the linear dimensions measured at the ear, the greatest variability is the *lobular width* and the *intertragic distance*. At the opposite pole, the *physiognomic length* and the *morphological length* of the ear are the least variable dimensional parameters. Also, the linear dimensions of the left ear are slightly larger than those of the right ear.

From angles analysis results that the angle with the greatest variability in the population is the angle between the physiognomic length and the morphological length of the ear.

Indexes analysis shows a greater dispersion of the values for the conchal and lobular indices, which shows a greater variability of the forms in these regions.

In order to prove the ear uniqueness we performed a correlation analysys that indicates a few correlations between ear parameters.

Ear width, lobe height, concave length, and morphological length of the ear are the most independent parameters, so they can be considered first in identification procedures.

DECLARATION OF INTERESTS

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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