The North African Journal of Scientific Publishing (NAJSP)
مجلة شمال إفريقيا للنشر العلمي (NAJSP)
E-ISSN: 2959-4820
Volume 3, Issue 1, January - March 2025
Page No: 161-168
Website: https://najsp.com/index.php/home/index
SJIFactor 2024: 5.49 معامل التأثير العربي (AIF) 2024: 0.71 ISI 2024: 0.696

Impact of Environmental and Physiological Factors on Human Earlobe Traits in Benghazi, Libya

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تأثير العوامل البيئية والفسيولوجية على صفة شحمة الأذن لدى البشر في بنغازي، ليبيا

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Received: January 20, 2025	Accepted: March 10, 2025	Published: March 24, 2025

Abstract:
The study aims to collect and analyze data through a questionnaire covering multiple variables, including gender, age, weight, height, blood type, region, and parental consanguinity, to assess their influence on the earlobe attachment trait. The study was conducted in three coastal regions of Benghazi and targeted students from Benghazi University and its branches. A total of 1,326 individuals participated, and family-related data of university students were also considered. The study investigated whether environmental and social factors, such as consanguineous marriages, affect the studied trait. After data collection, statistical analysis was performed using SPSS, including Chi-square calculations. The results indicated statistically significant associations for weight, region, gender, and parental consanguinity, with Chi-square values of 10.663, 11.873, 11.51, and 77.07, respectively, at $P < 0.05$. The highest prevalence of free earlobes was observed in females (51.2%), the second weight category (49.1%), the third height category (67.8%), and individuals with no parental consanguinity (63.25%). In contrast, attached earlobes were most prevalent in specific blood types (41.3%) and regions (89.1%). Additionally, correlation coefficients between these traits and earlobe attachment showed an inverse relationship: -0.065 (weight categories), -0.021 (regions), and -0.008 (gender). However, only the correlation between weight categories and earlobe attachment was statistically significant. This suggests that earlobe inheritance follows an independent genetic pattern, except for the influence of weight categories, which showed a significant association.

Keywords: Environmental and physiological factors, Correlation coefficients, Chi-square, Earlobe traits, Libyan individuals.

الملخص
هدفت هذه الدراسة الميدانية على تعبئة استبيان متضمن عدة نقاط منها الجنس والعمر والوزن والطول والفصيلة الدم والمنطقة وصلة قرابة الابوين وتأثيرها على صفة شحمة الاذن حيث شملت الدراسة ثلاث مناطق في ساحل مدينة بنغازي واستهدفت طلاب كليات جامعة بنغازي وفروعها. وقد شملت الدراسة البيانات الاسرية الخاصة بطلبة جامعة بنغازي في بعض كلياتها، حيث تم جمع البيانات من 1326 شخص. وتمت متابعة ما إذا كانت الظروف البيئية والاجتماعية مثل زواج الأقارب إذا تؤثر على الصفة المدروسة شحمة الاذن. بعد جمع البيانات تم تحليلها احصائيا بواسطة برنامج SPSS وحساب مربع كاي لهذه البيانات والحصول على النتائج التالية حيث لوحظ دلالة احصائية لكل من الوزن والمنطقة والجنس وصلة القرابة التي قدرت نتائجهن (10.6 – 11.873 – 11.51 – 77.07) بالتوالي عند القيمة الاحتمالية P < 0.05. كما لوحظ إن اعلى نسب لشحمة الأذن المنفصلة كانت عند جنس الاناث و فئة العمرية الثانية للوزن و فئة العمرية الثالثة للطول و لا توجد صلة قرابة (51.2 –49.1 –67.8 – 63.25) على التوالي و اعلى نسبة لشحمة الأذن المتصلة عند فصيلة الدم و المنطقة بقيمة (41.3–89.1) على التوالي , بالإضافة إلي قياس معامل الارتباط بين هذه الصفات مع شحمة الاذن الذي استنتج أنها علاقة عكسية , حيث قدرت (- 0.065) – (-0.021) – (-0.008) لكل من فئات الوزن و المناطق و الجنس على التوالي , بالرغم أن استنتاج الارتباط بين الصفة فئات الوزن مع شحمة الاذن ذو دلالة احصائية فقط , مما يدل على أن وراثة شحمة الاذن هي نمط وراثي مستقل في الصفات المدروسة ماعدا صفة فئة الاوزان فهي ذات ارتباط معنوي .

الكلمات المفتاحية: العوامل البيئية والفسيولوجية، معامل الارتباط، مربع كاي، صفة شحمة الأذن، العشيرة الليبية.

Introduction

The human ear is a vital organ of the sensory nervous system, playing a crucial role in both hearing and balance. The external ear, particularly its shape and attachment to the head, varies significantly among individuals, contributing to unique physical appearances. The outer ear consists of three main parts, one of which is the earlobe. Based on its attachment to the head, the earlobe has been classified into different types.

The classification of earlobe attachment has been a subject of genetic studies since the 1920s. Traditionally, earlobes have been categorized into two primary types: free and attached. This distinction was initially thought to follow a simple Mendelian inheritance pattern, where the free earlobe was considered a dominant trait, while the attached earlobe was recessive. Early genetic studies suggested that earlobe attachment was controlled by a single gene. Therefore, it was frequently used as a model for illustrating fundamental genetic inheritance principles.

However, subsequent research, particularly in the 1930s, challenged this simplistic view. Studies demonstrated that earlobe attachment exhibits greater variation than initially assumed, involving multiple types and complex distribution of attachment points rather than just two distinct categories such as (Wiener 1937), and more recent ones, such as (El Kollali 2009), acknowledged the existence of three types of earlobe traits rather than just two, then (Dutta and Ganguly 1965), (Purkait and Singh, 2008) disagreed with them, asserting that the trait follows the principle of polygenic inheritance. Further genetic analysis, including a meta-analysis of 74,660 individuals from multiethnic populations, identified 49 genomic loci associated with earlobe morphology (Shaffer, et al 2017), (Shaffer, et al 2016), (kim, et al 2018). These findings indicate that earlobe attachment is a polygenic trait, influenced by multiple genes and their interactions rather than a single Mendelian gene. Additionally, environmental factors and random genetic variations may contribute to the diversity of earlobe characteristics.

The study of earlobe traits has broader significance beyond genetics. Understanding the genetic basis of earlobe variation provides insights into ear development and congenital conditions affecting ear morphology. It also serves as an example of the contrast between simple and complex inheritance patterns, making it relevant in educational and medical genetics (Shaffer et al., 2017). Several studies worldwide have explored the association between earlobe morphology and physiological factors such as gender, age, and blood type (Krishan et al, 2014).

In fact, the population diversity of humans living in various geographical regions provides a valuable opportunity to study the phenotypic variation among local populations residing in different geographical and environmental conditions (Bhasin and Khanna, 1994).

Despite extensive research in different populations, studies on earlobe morphology in Libya remain limited. Given this gap, the present study aims to examine the influence of environmental and physiological factors on earlobe traits among Libyan individuals. Specifically, this research investigates whether factors such as gender, age, weight, height, blood type, geographic region, and parental kinship affect earlobe morphology. Data collection was conducted through a structured questionnaire to systematically assess these relationships.

Material and Methods
Study Area and Participants
This study was conducted on a randomly selected sample of 1,326 participants (650 males and 676 females) from Benghazi and its surrounding areas, including Suluq and Tokra. Data collection was carried out by students from the University of Benghazi and its branches in Suluq, Tokra. The participants resided in 40 different areas, with some living up to 100 kilometers away from the university. The study was conducted in four phases:

- First phase (2013-2014): Faculty of Science and Agriculture, Suluq Branch.
- Second phase (2016-2017): College of Arts and Sciences, Tokra Branch.
- Third phase (2018-2022): Several colleges at the University of Benghazi.

The study sample included students, employees, and lecturers along with their families, excluding children. Ethical approval was obtained from the university's research ethics committee, and all participants voluntarily provided written informed consent before participation.
Study Design
This study was conducted using a questionnaire distributed among the targeted sample. Participants completed the questionnaire after receiving a brief explanation of the research objectives. The questionnaire collected information on the presence of a free or attached earlobe pattern among participants and examined its correlation with various factors, including gender, weight, blood group, and the degree of kinship between their parents.
Statistical Analysis:
The data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 20.0. Frequencies and percentages were calculated and presented in various cross-tabulations. The Chi-square (χ^2) test was employed to evaluate the influence of different variables on the distribution of human ear features. Additionally, Spearman correlation coefficients were computed to determine significant relationships between variables. A p-value of less than 0.05 was considered statistically significant.
Results
The study was conducted over different time intervals from 2013 to 2022, covering different geographic locations in each period, namely Suluq, Tokrah, and Benghazi. A total of 1,326 participants from the University of Benghazi and its branches were included in the study, employees, and lecturers along with their families, excluding children. Among them, 941 individuals (70.97%) exhibited the phenotype of detached earlobes, while 385 individuals (29.03%) exhibited attached earlobes, as shown in Table The table 1 presents the total number of participants, distributed by gender across the three main regions.

In the University of Benghazi, 1,129 cases were examined, consisting of 590 males (418 with detached earlobes and 172 with attached earlobes) and 539 females (368 with detached earlobes and 171 with attached earlobes). In Tokrah, 156 cases were recorded, with 43 males (28 with detached earlobes and 15 with attached earlobes) and 113 females (100 with detached earlobes and 13 with attached earlobes). Finally, in Suluq, 41 cases were recorded, including 17 males (13 with detached earlobes and 4 with attached earlobes) and 24 females (14 with detached earlobes and 10 with attached earlobes)

The percentage of individuals with attached earlobes among males was (50.1% – 53.6% – 28.6%), while those with detached earlobes were (53.2% – 21.9% – 48.1%). Among females, the percentage of individuals with attached earlobes was (49.9% – 46.4% – 71.4%), and those with detached earlobes were (46.8% – 78.1% – 51.9%) across the three geographic locations, respectively. The prevalence of detached earlobes was higher than that of attached earlobes in both males and females, with (482 – 459) and (194 – 191) cases, respectively. The highest percentage of detached earlobes was observed in males from Benghazi (53.2%) and females from Tokrah (78.1%), whereas the highest percentage of attached earlobes was found in males from Tokrah (53.6%) and females from Suluq (71.4%).

The average height of participants was (166 ± 12.3) cm, with a general range between 122 cm and 195 cm. The average height of individuals with detached earlobes was (167 ± 12.1) cm, whereas those with attached earlobes had an average height of (165 ± 12.7) cm. Additionally, the overall average weight was (69 ± 14.7) kg, with individuals exhibiting detached earlobes having an average weight of (68 ± 14.2) kg, while those with attached earlobes had an average weight of (71 ± 15.8) kg. Table 1 presents the total number of individuals, the number of males and females, and their percentage in each region for the earlobe trait, as well as the average weight and height.

Table 1: The total number of individuals, the number of males and females, and their percentage in each region for the earlobe trait, as well as the average weight and height.

	Unattached N (%)		Attached N (%)		Total
Area	F	M	F	M	
Sex					
B	368 (46.8)	418 (53.2)	171 (49.9)	172 (50.1)	1129
T	100 (78.1)	28 (21.9)	13 (46.4)	15 (53.6)	156
S	14 (51.9)	13 (48.1)	10 (71.4)	4 (28.6)	41
Total	482	459	194	191	1326
	941(70.97%)		385(29.03%)		
	Mean±SD				
Body weight	68 ± 14.2		71 ± 15.8		69 ± 14.7
Height	167 ± 12.1		165 ± 12.7		166 ± 12.3

F: femal, M: male, % percentage, N: numbe

Table 2 illustrates the relationship between earlobe phenotype and various factors, including gender, weight, height, blood type, and parental consanguinity. The Chi-square (χ^2) value for gender was calculated, and the relationship between earlobe type and gender was tested with $\chi^2 = 11.51$ based on Mendelian 3:1 distribution. This indicates a statistically significant association between earlobe type and gender at a significance level of $P < 0.05$. The results further showed that the Chi-square values for males and females were statistically significant, estimated at (6.67 and 4.93), respectively. The table also approximates the total number of males and females, showing nearly equal distribution: 676 (51.0%) males and 650 (49.0%) females. The prevalence of detached earlobes was higher than that of attached earlobes in both males and females, with (482 – 459) and (194 – 191) cases, respectively.
Additionally, the Chi-square values for weight categories were calculated by dividing weight into five groups. The relationship between earlobe type and weight category was tested, yielding $\chi^2 = 10.663$, indicating a statistically significant association at $P < 0.05$. The highest number and percentage of cases were found in the second age group, followed by the first, third, fourth, and fifth age groups, with respective values of 637 (48%), 445 (33.6%), 212 (16%), 29 (2.2%), and 3 (0.2%), regardless of whether the earlobe was attached or detached.
For height, the Chi-square values were calculated by dividing height into four categories. The relationship between earlobe phenotype and height was tested, yielding $\chi^2 = 2.26$, indicating no statistically significant association at $P < 0.05$. The highest number and percentage of cases were observed in the third height category, followed by the second, first, and fourth categories, with values of 884 (66.7%), 402 (30.3%), 31 (2.3%), and 9 (0.7%), respectively, regardless of earlobe type.
The table 2 presents the Chi-square values for blood type. The relationship between earlobe type and blood type was tested with $\chi^2 = 3.929$, indicating no statistically significant association at $P < 0.05$. The highest number of participants was found in blood groups A, O, B, and AB, in descending order: A (512, 38.6%), O (482, 36.3%), B (252, 19.0%), and AB (80, 6.0%).

Table 2: The Chi-square values for the studied traits, along with the total number of individuals, males, and females for the earlobe trait.

parameters		Attached % (N)	Unattached % (N)	Total	x^2
Sex	F	(50.4%) 194	(51.2%) 482	(%51) 676	11.51*
	M	(49.6%) 191	(48.8%) 459	(%49) 650	
		%100	%100	%100	
Weight					
60-41		(31.2%) 120	(34.5%) 325	(%33.6) 445	10.663*
80-61		(45.5%) 175	(49.1%) 462	(%48) 637	
100-81		(19.7%) 76	(14.5%) 136	(%16) 212	
120-101		(3.10%) 12	(1.80%) 17	(%2.2) 29	
> 120		(0.50%) 2	(0.10%) 1	(%0.2) 3	
		%100	%100	%100	
Height					
130-100		(2.6%) 10	(2.2%) 21	(%2.3) 31	2.26
160-131		(33.0%) 127	(29.2%) 275	(%30.3) 402	
190-161		(63.9%) 246	(67.8%) 638	(%66.7) 884	

> 190	(0.50%) 2	(0.7%) 7	(%0.7) 9	
	%100	%100	%100	
Blood group				
A	(41.3%) 159	(37.5%) 353	(%38.6) 512	3.929
B	(20.5%) 79	(18.4%) 173	(%19) 252	
AB	(5.5%) 21	(6.3%) 59	(%6) 80	
O	(32.7%) 126	(37.8%) 356	(%36.4) 482	
	%100	%100	%100	
Area				
B	(%89.1)343	(83.5%)786	(85.1%) 1129	12.139*
T	(7.3%)28	(13.6%)128	(11.8%) 156	
S	(3.6%)14	(2.9%)27	(3.1%) 41	
	%100	%100	%100	
Relationship parents				
+	(47.5%) 19	(36.75%) 61	(%38.8) 80	77.07*
-	(52.5%) 21	(63.25%) 105	(%61.2) 126	
Total	%100	%100	%100	

* chi square tab. (df-1 p 0.05)

Furthermore, the table illustrates the Chi-square values for geographic regions, dividing the participants into three main locations. The relationship between earlobe type and region was tested, yielding χ^2 = 12.139, indicating a statistically significant association at $P < 0.05$. The highest number and percentage of cases were observed in the University of Benghazi region, followed by Tokrah and Suluq, with respective values of 1,129 (85.1%), 156 (11.8%), and 41 (3.1%).
Lastly, the table presents the Chi-square values for parental consanguinity, categorized into two groups. The relationship between earlobe type and parental consanguinity was tested, yielding χ^2 = 77.07, indicating a statistically significant association at $P < 0.05$. The highest number and percentage of individuals were found among those whose parents were not consanguineous (126, 61.2%), compared to those with consanguineous parents (80, 38.8%).
Table 3 presents Spearman's correlation coefficient, which measures the strength and direction of the relationship between the studied traits and earlobe phenotype. The analyzed traits include weight, height, blood type, gender, geographic region, and parental consanguinity, in relation to earlobe type.
The correlation coefficients for these traits were estimated as follows: (-0.065), (0.041), (-0.041), (-0.008), (-0.021), and (0.087), respectively, at a significance level of $P < 0.05$.
The results indicate a negative correlation between earlobe type and weight, geographic region, and blood type, suggesting an inverse relationship. In contrast, a very weak correlation was observed between earlobe type and gender. Meanwhile, a weak positive correlation was found between earlobe type and both height and parental consanguinity.

Table 3: The correlation coefficient between the studied traits and the earlobe trait.

Ear lobe	weight	Height	Blood group	Sex	Area	Kinship
Correlation coefficient	-0.065*	0.041	-0.041	-0.008	-0.021	0.087
P-value	0.019	0.137	0.133	0.783	0.449	0.212
N	1326	1326	1326	1326	1326	206

* Chi square tab. (df-1 p 0.05)

Discussion

Undoubtedly, the phenotype always results from the interaction between genetic makeup and environmental factors (Sykes, 1993). However, the contribution of genetic factors varies depending on their number, pleiotropic effects, and the influence of permanent and temporary environmental factors in shaping the final phenotype. Therefore, it is essential to determine whether the 49 gene loci identified by Shaffer et al. (2017), along with the additional six loci discovered in a subsequent study, play a role in earlobe morphology among the studied traits (Shaffer et al., 2017).
The study highlights the significance of phenotype analysis, which is a key focus for many researchers due to its biological importance in determining biometric measurements, addressing abnormal conditions, and understanding the impact of environmental factors on metric traits and gene expression. Additionally, a later study identified 16 more genetic loci associated with earlobe traits, increasing the total number of morphological traits related to the ear to 136 (Qian et al., 2023).

This study aimed to assess the phenotypic variation among students and their parents concerning the studied traits by using the Chi-square test. It sought to determine the relationship between these traits and earlobe morphology through a questionnaire distributed among 1,326 cases, covering students and their parents from Benghazi University and its branches. The study population was categorized into three major geographic regions: Benghazi, Tokra, and Suluq.

The results showed a nearly equal distribution of males (650, 49%) and females (676, 51%). The percentage of individuals with free earlobes was 70.97%, while those with attached earlobes accounted for 29.03%. These findings were very close to those reported by El-masli and Bokhamada (2021), who estimated free earlobes at 69.4% and attached earlobes at 30.6%. Similarly, Kooffreh et al. (2015) reported free and attached earlobe percentages of 69.2% and 30.8%, respectively. The results also align with those of Ordu et al. (2014), who estimated 74.14% for free earlobes and 25.86% for attached earlobes. However, the results differed from Mohamed et al. (2024), who found 42.3% for attached earlobes and 57.7% for free earlobes. This discrepancy could be attributed to differences in sample sizes (449 vs. 612) in comparison to the present study. Additionally, Sudan et al. (2021) estimated 60.41% for free earlobes and 39.59% for attached earlobes. The study's findings were significantly different from those reported by Kaur et al. (2022), who found that free and attached earlobe percentages were 86.08% and 13.92%, respectively.

The overall Chi-square value for gender was 11.5, indicating a high statistical significance, similar to Mohamed et al. (2024), who reported a value of 169.7 with a comparable sample size. The statistical significance was more pronounced in males than females, with Chi-square values of 6.67 and 4.93, respectively. The percentage distribution of free and attached earlobes between males and females was close (48.8%–49.6% and 51.2%–50.4%, respectively). These results differed from those of Rani et al. (2020), who found that free earlobes were more common in males (53.52%) than in females (38.03%), with attached earlobes being distributed as 46.38% in males and 47.83% in females. Similarly, Asiwe et al. (2023) reported male and female distributions of 57.8%–42.2% and 48.8%–51.6%, respectively. In contrast, Kooffreh et al. (2015) found no significant relationship between gender and earlobe morphology (Chi-square = 0.31). Similar findings were reported by Asiwe et al. (2023) (Chi-square = 3.39) and Irozulike et al. (2024) (Chi-square = 1.652).

Regarding body weight, the highest percentage of participants belonged to the 61–80 kg category, with overall and trait-specific distributions of 48%, 49.1%, and 45.5%, respectively. In terms of height, the highest percentage was observed in the 161–190 cm category, with values of 66.7%, 67.8%, and 63.9%, respectively. Geographically, students from Benghazi had the highest representation, with overall and trait-specific distributions of 85.1%, 89.1%, and 83.5%, respectively.

The most common blood type among all participants was blood type A, with a frequency of 512 (38.6%), followed closely by blood type O at 482 (36.3%). Among individuals with free earlobes, blood type O was the most common (356, 37.8%), followed closely by blood type A (353, 37.5%). Conversely, among those with attached earlobes, blood type A was most common (159, 41.3%). This finding contradicts the results of Al-Abbas et al. (2017), who found that blood type O was the most prevalent across all categories. Similarly, Kooffreh et al. (2015) reported that blood type O was the most common among the total population, males, and females. Their Chi-square value (8.18) indicated a statistically significant relationship between blood type and earlobe morphology, unlike the present study, which found a lower Chi-square value (3.929). It was found that the reason is the difference in proportions between attached and detached earlobes. The ranking of blood group proportions for detached earlobes in the study by Kooffreh et al. (2015) was (O → A → B → AB), which is similar to our study. However, the ranking for attached earlobes in their study was (O → B → A → AB), which differs from our study, where the ranking was (A → O → B → AB). This significant variation in the second trait greatly influenced the Chi-square value estimation. Additionally, our results differed from those of Krishna et al. (2014) regarding the ranking of blood group proportions, as well as from the study by Anchinmane and Sankhe (2022).

The highest percentage of cases involved non-consanguineous marriages, accounting for 61.2% of the total population. This group also exhibited the highest percentage of free and attached earlobes compared to consanguineous marriages, with respective values of 63.25% and 52.5%.

Chi-square values indicated statistical significance for gender, weight categories, geographic regions, and consanguinity, with values of 11.51, 10.663, 12.139, and 77.07, respectively, at a significance level of $P < 0.05$. These results align with those of El-masli and Bokhamada (2021), who reported a Chi-square value of 23.2 for gender, but contradict Kooffreh et al. (2015), who found a non-significant Chi-square value of 0.31 for gender.

Previous studies have suggested that ear circumference increases by 0.51 mm per year with age, indicating a strong relationship between height and weight, both of which have statistical significance with earlobe morphology (Tan et al., 1997). However, no significant association was found between height and earlobe type, in agreement with Azaria et al. (2003).

The correlation coefficients between the studied traits and earlobe type were negative, except for consanguinity and height, where positive correlations were observed (0.087 and 0.041, respectively). Weight was the only trait that showed a significant correlation with earlobe type (Spearman's correlation coefficient = -0.065). These findings align with Azaria et al. (2003), who reported a statistically significant relationship between weight and earlobe type in females, and with Sharma et al. (2008), who found that earlobe thickness, length, and width change with age, correlating with weight gain over time.

The geographic region was independently correlated with earlobe morphology (correlation coefficient = -0.021), suggesting that genetic diversity across regions might influence earlobe morphology either directly or indirectly. No significant correlation was found between gender and earlobe type, consistent with the findings of Kaur et al. (2022), Verma et al. (2016), Asiwe et al. (2023), and Irozulike et al. (2024), but differing from Kim et al. (2018) and El-masli and Bokhamada (2021), who reported a significant interaction between gender and region in relation to the studied trait.

Conclusion

This field study examined how environmental and physiological factors influence earlobe traits among University of Benghazi students. Factors analyzed included gender, weight, height, blood type, region, and parental consanguinity. Statistical analysis (Chi-square) showed significant associations with weight, region, gender, and kinship. Unattached earlobes were more common among females, individuals in the second weight category, the third height category, and those without parental consanguinity. Attached earlobes were most frequent among individuals with blood type A and from Benghazi. The study concluded that earlobe inheritance follows an independent genetic pattern, except for a significant correlation with weight class. These findings could contribute to scientific and medical databases for university students.

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