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INVESTIGATING THE INHERITANCE PATTERNS AND POTENTIAL ASSOCIATIONS OF SELECTED HUMAN MORPHOGENETIC TRAITS

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Abstract *This research analyses the distribution, inheritance patterns, and potential associations between various physical characteristics (Handedness, Hand-clasping, Tongue-rolling, tongue folding and Hitchhiker's thumb, Mid-phalangeal hair, bent little finger, Cleft chin, Widow's peak, earlobe attachment & Dimpled cheeks) in students from the Faculty of Agriculture Sciences. The Chi-square was used of independence to assess inheritance patterns and potential links. The findings reveal interesting patterns: some recessive traits viz; Mid-phalangeal hair, bent little finger, Cleft chin, Widow's peak, earlobe attachment & Dimpled cheeks were more common than their dominant counterparts. In contrast, dominant features such as handedness, hand-clasping, tongue-rolling, tongue folding, and hitchhiker's thumb were found more frequently. There is also a significant relationship between morphogenetic features (tongue rolling, mid-phalangeal hair, and widow's peak) and gender. The current study has implications for several disciplines, including human genetics, forensics, and anthropology. Establishing a baseline for this specific population size group allows for future investigation into human variety and the intriguing realm of inheritance.*

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Introduction

Human beings exhibit a remarkable diversity of physical characteristics, like facial features, fingerprints, and earlobes. These observable features are also known as morphogenetic traits, many of which are determined by one or more genes and are inherited through dominant and recessive alleles of one gene, forming 'Mendelian traits' that are passed down through generations (Anna, 1976; Chhikara and Yadav, 2012; DEVI and VANKARA, 2022). Certain traits, such as hitchhiker's thumb, handedness & bent little finger also known as polygenic traits, are considered non-mendelian due to their alleles located on multiple genes (Bama, 2021). These morpho-genetic traits are a huge source of genetic variation in Humans (Usha et al., 2016). These are often influenced by factors like environment, migration, selection, gene flow, Independent assortment, and genetic drift (Bhasin and Khanna, 1994; Eboh, 2017). Studying the inheritance patterns of these traits can shed light on the underlying genetic mechanisms and their potential variations across populations. Several studies have explored the inheritance patterns of various human morphogenetic traits. For instance, (Adekoya et al., 2020) investigated the distribution of earlobe attachment, polydactyly, widow's peak, Cleft chin, and other traits in the Nigerian student population, revealing Mendelian inheritance patterns for some characteristics. Similarly, a significant Association Between Tongue Rolling and Tongue Folding in the Yoruba tribe of Southwestern Nigeria (Igbeneghu et al., 2016), suggesting a potential link between these traits, similar findings were presented in the African population by (Odokuma et al., 2008). However, another case study in Andhra Pradesh opposes the above findings as there is no association was found between these two traits (Alabi et al., 2020; Bulliyya, 2003) found an association between fingerprints and lip print patterns providing an alternative for fingerprints to identify suspects.

Despite these existing investigations, a comprehensive analysis of inheritance patterns and potential associations across a wider range of human morphogenetic traits remains necessary as it cleared from the above findings that the mechanism controlling the inheritance of these traits is still un-cleared because of differential expression of these traits in Different population of the World. This study aims to address this gap by investigating the inheritance patterns and potential inter-trait

associations of a selection of commonly studied human morphogenetic traits within specific demographics. The student population of the Faculty of Agriculture Sciences presents a unique opportunity for such research. Students within this faculty likely share certain environmental factors and potentially some genetic predispositions related to their chosen field of study. Investigating morphogenetic traits within this group can reveal interesting associations and inheritance patterns that might not be as evident in a more general population sample.

This study aims to explore the inheritance patterns of selected human morphogenetic traits among students enrolled in the Faculty of Agriculture Sciences at the University of Punjab, Lahore. By analyzing a representative sample population, we aim to: Identify the inheritance patterns for a range of morphogenetic traits, including handedness, earlobe attachment, tongue-rolling ability, and others. Explore potential associations between these traits and factors like gender or other easily observable characteristics. Contribute to the existing body of knowledge on human genetic variation and potential links between morphogenetic traits and health.

Furthermore, this research contributes to the ongoing exploration of human genetic diversity and the interplay between genetics and environment. By focusing on a specific student population, we can gain a deeper understanding of how these factors influence the expression of morphogenetic traits.

Material and Methods

Study Design and Participants

This study employed a cross-sectional survey design to investigate the inheritance patterns and potential associations of selected human morphogenetic traits among students of the Faculty of Agriculture Sciences. A sample of 300 students was recruited through a random sampling process, ensuring that students from various departments within the Faculty were represented.

Data Collection

To gather data for this research, a custom online Google Form was designed to anonymously and efficiently collect information from participants. The form included several sections. First, a demographic information section offered participants the option to provide their names for potential future studies (with their consent). This was followed by a department selection using a dropdown menu listing all departments within the Faculty of Agriculture Sciences (Entomology, Plant Breeding and Genetics, Agronomy, Soil Science, Plant Pathology, and Horticulture). Participants then selected their gender identity from options including "Male," "Female," The core of the form focused on morphogenetic traits. Eleven multiple-choice questions were included, each targeting a specific trait with unambiguous answer choices. The traits investigated were: handedness (right-handed or left-handed), hand clasping (right or left thumb on top), hitchhiker's thumb (present or absent), bent little fingers (bent or straight), mid-phalangeal hair (present or absent), tongue rolling (Roller or Non-Roller), tongue folding (Folder or Non-Folder), cleft chin (present or absent), dimpled cheeks (present or absent), earlobe attachment (attached or free), and hairline (straight or Widow's peak).

Statistical Analysis

The collected data from the Google Form was exported to Excel for data organization and further analysis. Descriptive statistics were employed to summarize the distribution of participants by department, gender, and for each morphogenetic trait. The frequencies and percentages of individuals exhibiting each phenotypic expression (e.g., right-handed, bent little fingers on both hands) were calculated. Further Chi-square tests of independent association were applied to assess potential associations between categorical variables, such as gender and the presence/absence of a specific trait (e.g., cleft chin) and among Traits like facial traits, tongue traits, etc.

Ethical Considerations

This study adhered to ethical research principles. Participation in the online survey was voluntary and anonymous. Informed consent was considered implied by participants completing and submitting the survey. All data were stored securely and confidentially. The study protocol was reviewed and approved by the Head of the Department of Plant Breeding and Genetics before the data collection commenced.

Result and Discussion

Frequency distribution of evaluated traits in the sample population

The results provide clear insight into the expression of all Traits in each individual in a sampled population. Table 1 shows the distribution of 11 morphogenetic traits in a population. There were a total of 300 individuals (190 males and 110 females). Out of which 81.67% of the sample were right-handed and 18.33% were left-handed. Many case studies reported the same results which provided more proof in favour of right-handedness (Chadha and Sandhu, 2013; Petricevic and Cvjeticanin, 2011; Usha et al., 2016). Moreover, 79.33% of the sample clasped their hands with their right thumb on top, while 20.67% clasped with their left thumb on top. These findings are consistent with the previous studies as Extensive research by(Lai and Walsh, 1965; Pons, 1961) exhibits that the right thumb on top occurs most frequently, also no significant Gender differences are found in many studies (Beckman and Elston, 1962). For Hitch hiker's thumb, 61.67% of the individuals have single-jointed thumb, and 38.33% exhibited the double-jointed trait and it also validates the results of previous studies (Adekoya et al., 2020; DEVI and VANKARA, 2022; Onyije et al., 2012). Only 32.33% of the sample had

bent little fingers which also confirms the results of many researchers (Adekoya et al., 2020; Onyije et al., 2012; Ordu and Nwosu, 2015). Findings of our study and (Adekoya et al., 2020) showed that both straight and bent little fingers were prevalent in males rather than females. Findings also showed that 36.33% of the sample had mid-phalangeal hair, and 63.67% did not. These findings corroborate the results of (Aboagye et al., 2013; DEVI and VANKARA, 2022), and (Umoyen et al., 2021). The freq. distribution of both tongue traits reveals the presence of more tongue rollers (71.67%) and folders (61.33%) and this also verifies the findings of (Adekoya et al., 2020; Eboh, 2017; Odokuma et al., 2008). However (Razzaq et al., 2015) opposed the above findings. The result showed that only 27.33% of individuals had cleft chins. Likewise, only 15% of the sample had facial dimples. 34.33% of the sample had attached earlobes, and 65.67% had free earlobes. 47.33% of the sample had a widow's peak hairline. These three dominant facial traits (cleft, dimples, and widow's peak) occurred in less frequency while the dominant trait free-ear lobe appeared in high frequency. These results are in consonance with previous studies(Adekoya et al., 2020; DEVI and VANKARA, 2022).

Fig 1. A visual guide to understanding commonly observed phenotypic traits in human

Table 1. Distribution Of Observed Morphogenetic Traits In The Sampled Population

Morphogenetic Traits	Phenotype	Frequency(N)	Percentage(%)
Gender	Male	190	63.33
	Female	110	36.67
Handedness	Right hand	245	81.67
	Left Hand	55	18.33

Hand Clasping	Right thumb on top	238	79.33
	Left thumb on top	62	20.67
Hitch hiker's thumb	Single jointed	186	61.67
	Double Jointed	114	38.33
Bent Little Fingers	Bent	97	32.33
	Straight	203	67.67
Mid-Phalangeal Hair	Present	109	36.33
	Absent	191	63.67
Tongue Rolling	Roller	215	71.67
	Non-Roller	85	28.33
Tongue Folding	Can Fold	184	61.33
	Can't Fold	116	38.67
Cleft chin	Cleft	82	27.33
	Smooth	218	72.67
Dimpled Cheeks	Dimple	45	15.00
	No Dimple	255	85.00
Earlobe Attachment	Attached	103	34.33
	Free	197	65.67
Hair line	Widow's Peak	142	47.33
	Straight	158	52.67

Distribution of inheritance pattern of morphogenetic traits evaluated

The distribution of inheritance pattern of the selected traits revealed that out of 11 traits 6 traits namely; Handedness, Hand clasping, Tongue rolling, tongue folding, and Hitchhiker's thumb and earlobe attachment Showed Dominance pattern and the other 5 traits viz; Mid-phalangeal hair, bent little finger, Cleft chin, Widow's peak & Dimpled cheeks rather expressed less in the sampled population(Fig.2). Further-more dominantly expressed phenotypes of the studied traits were higher in males except for Earlobe attachment and in case of recessively expressed traits there was less no of males individuals for Hair line and Dimpled cheeks while for the rest three trait, there were higher male individuals.

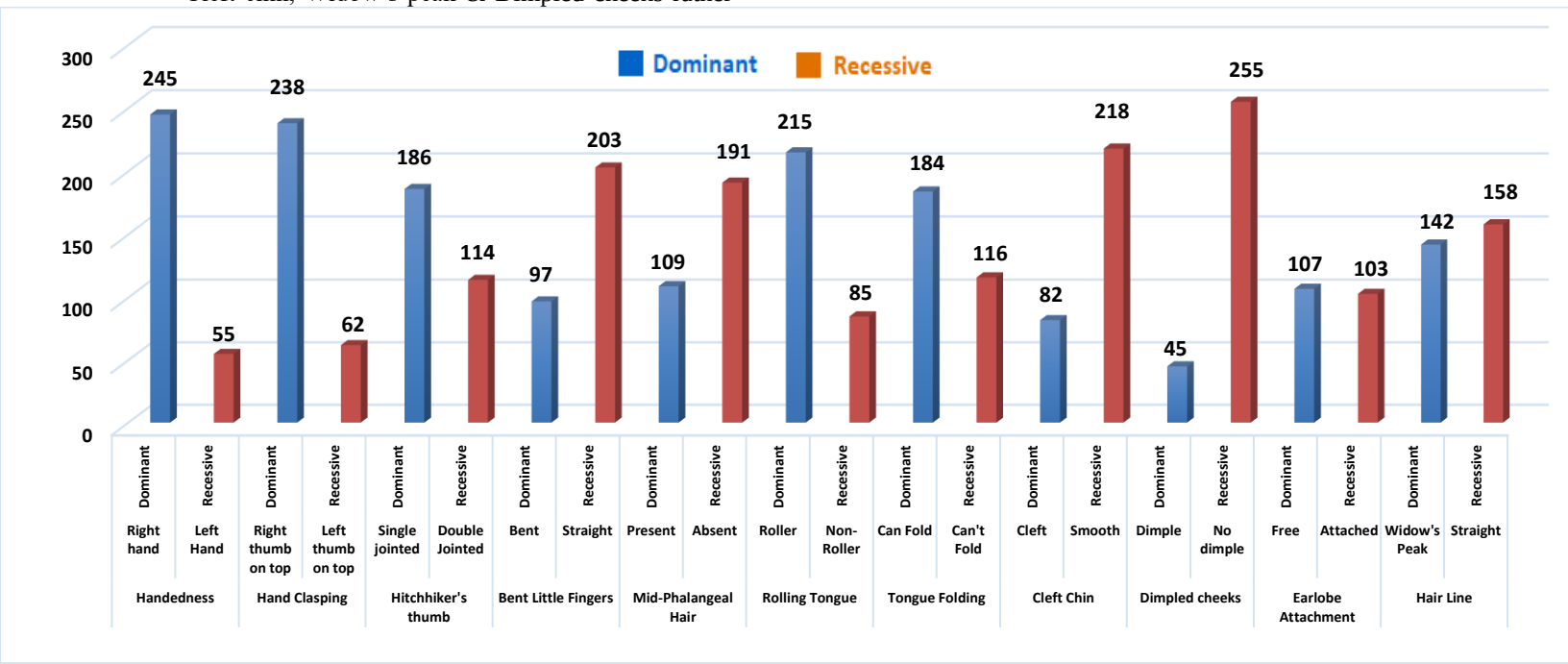

Fig 2: Distribution of dominance & recessiveness of studied traits in the sampled individuals

Gender association with the studied traits

Table 2 shows the results of a chi-square test of independence between gender and several morphological traits in a population of 300 individuals. The results showed that all the traits are not significantly correlated with (P>0.05) except for the Mid-phalangeal hair, Tongue rolling, and Widow's peak trait. There was a statistically

significant association between mid-phalangeal hair and gender ($X^2(1) = 5.222$, $p = 0.022$). The prevalence of having no phalangeal hair is higher in males than females. For Tongue rolling there was a significant association between tongue rolling and gender ($X^2(1) = 4.102$, $p = 0.042$). Males were more likely to be able to roll their tongues than females. Also, a significant association between hairline and gender ($X^2(1) = 4.613$, $p = 0.032$) is noticed in the present case study. Similar results were published by(Nwaopara et al., 2008) while studying a population of Ekpoma, Nigeria. However many previous findings opposed the present results(Anibor et al., 2015; Dutta, 1965; Nusbaum and Fuentefria, 2009). Moreover, Males were more likely to have a widow's peak hairline than females.

Table 2. Test of independent association between gender and evaluated traits in the population of study

Traits	Phenotype	Gender		$\mathcal{X}^2$(Chi-Square value)	P value(at 0.05 %)
		Male	Female		
Handedness	Right hand	150	95	0.341	0.56
	Left Hand	36	19		
Hand Clasping	Right thumb on top	167	71	1.791	0.18
	Left thumb on top	38	24		
Hitch hiker's thumb	Single jointed	110	76	2.869	0.09
	Double Jointed	56	58		
Bent Little Fingers	Bent	63	34	1.87	0.17
	Straight	115	88		
Mid-Phalangeal Hair	Present	60	49	4.65	0.03*
	Absent	129	62		
Tongue Rolling	Roller	114	101	4.102	0.04*
	Non-Roller	56	29		
Tongue Folding	Can Fold	107	77	0.946	0.33
	Can't Fold	74	42		
Cleft chin	Cleft	45	37	0.147	0.70
	Smooth	125	93		
Dimpled Cheeks	Dimple	16	29	1.416	0.23
	No Dimple	115	140		
Earlobe Attachment	Attached	54	49	2.343	0.13
	Free	85	112		
Hair line	Widow's Peak	85	57	4.613	0.03*
	Straight	75	83		

Association analysis of Hand traits

Test of independence association between Hand traits showed a significant association between handedness and hand clasping (chi-square = 30.89, $p < 0.01$). This means that there is a relationship between a person's handedness and which thumb they clasp on top when clasping their hands together. In simple words, right-handed People are more likely to clasp their right thumb on top, while left-handed are more likely to clasp their left thumb on top. These results do not align with those (Ogah et al., 2012). Similarly a study by (Loveland, 1974) also found no correlation between these traits. Twin studies by (Reiss, 1999)provide strong evidence against the genetic influence on hand clapping. Based on these findings, we can assume that both hand traits could not be considered a simple genetic traits but are influenced by multiple factors that need to be explored.

Association analysis of tongue traits

The Analysis showed a significant association between tongue folding and tongue rolling (chi-square = 11.24, $p < 0.01$. Similar results were shown by(DEVI and VANKARA, 2022). People who can fold their tongue are also more likely to be able to roll it and are prevalent in this study which is also supported by the previous study in Osogbo, Southwestern Nigeria (Igbeneghu et al., 2016).Based on previous studies the genetic basis of tongue rolling and tongue folding is more than simple Mendelian genetics because there have been many contradictory opinions by various researchers. As (Hsu, 1948) reported tongue rolling and folding as dominant just like simple Mendelian genetics but (Liu and Hsu, 1949) identify tongue traits as recessive. While certain studies argue that these are not genetically determined but rather learned (Whittinghill, 1965). The heterogeneity in the expression of rolling and folding features indicates that their inheritance is more complex than simple genetics, possibly due to many genes or environmental influences.

Association analysis of Finger traits

The association analysis showed no significant correlation between mid-phalangeal hair and hitchhiker's thumb (chi-square = 3.06, $p > 0.05$) and also among mid-phalangeal hair and bent little fingers (chi-square = 3.01, $p > 0.05$). Conversely, a

significant association is present between hitchhiker's thumb and the bent little finger (chi-square = 5.66, p < 0.05). This result opposed the findings of(DEVI and VANKARA, 2022) but Comply with the results of (Adekoya et al., 2020).

Association analysis of Facial traits

The prevalence of Widow's peak is significantly correlated with both the Cleft chin(**χ^2=12.845, P<0.01)**) and Dimpled cheeks **(χ^2=6.22, P<0.01)**. More Individuals having Widow's peak were observed to have Smooth Chins than Cleft. Likewise, cleft chin and dimpled cheeks were found to be significantly associated with each other(**χ^2=5.90 , P<0.01)**. Furthermore, Earlobe attachment is independent of all the other facial traits. These results comply with the results of (Adekoya et al., 2020) But defy the findings shown by(DEVI and VANKARA, 2022) except for widow's peak and dimpled cheeks.

Conclusion

This study sheds light on how certain common physical characteristics are spread throughout the population. A study reveals that individuals with certain recessive traits, such as the widow peak, cleft chin, dimples, and bent fingers, are more likely to exhibit these traits than those with dominant traits. Conversely, dominant traits like tongue rolling, tongue folding, handedness, hand clasping, and Hitchhiker's thumb are more prevalent. It contributes to our understanding of genetic variations and unique traits within the studied group. This research is exciting because it has implications for several fields. Imagine how these findings could help us understand human genetics better, or even assist in forensic science. Future research could explore the reasons behind these differences, potentially aiding in understanding human evolution over time.

Table3: Test of independence association between Hand traits

Trait	**Phenotype**	**Hand Clasping**		**Chi (x^2) Value**	**P value**
		Right thumb on top	Left thumb on top		
Handedness	Right Hand	138	48	30.89**	**<0.01**
	Left Hand	48	66		

****p<0.01 , d.f =1**

Table4: Test of independence association between Tongue traits

Trait	**Phenotype**	**Tongue Rolling**		**Chi (x^2) Value**	**P value**
		roller	Non-roller		
Tongue folding	Can Fold	146	40	11.24**	**< 0.01**
	Can't Fold	69	45		

****p<0.01 , d.f =1**

Table 5: Test of independence association between finger traits

Trait	**Phenotype**	**Hitch hiker's thumb**		**Bent Little fingers**	
		Single jointed	**Double jointed**	**Bent**	**Straight**
Mid-Phalangeal Hair	Present	145	46	42	67
	Absent	76	38	55	136
		χ^2=3.06		**χ^2=3.01**	
Hitch hiker's thumb	Single jointed			78	108
	Double jointed			29	75
				χ^2=5.66*	

***P<0.05 , **p<0.01 , d.f=1**

Table 6: Test of independence association between facial traits

Trait	Phenotype	Clef Chin		Ear lobe attachment		Dimpled Cheeks	
		Cleft	Smooth	Free	Attached	Dimple	No dimple
Hair Line	Widow's Peak	25	117	87	55	29	113
	Straight	57	101	110	48	16	142
		χ^2=12.845**		**χ^2=2.31**		**χ^2=6.22****	
Clef Chin	Cleft			48	34	19	63
	Smooth			149	69	26	192
				χ^2=2.54		**χ^2=5.90****	
Ear lobe attachment	Free					24	173
	Attached					21	82
						χ^2=3.57	

****p<0.01 , d.f=1**

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Declarations

Declaration of Interest Statement

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Author's contributions

MAA, MAU and Aroosa conducted research and wrote initial draft of manuscript. AF, QA, AA, AUR, and MAA collected the literature and wrote the manuscript and edit the manuscript in original. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable

Consent for Publication

Not applicable