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Hardy-Weinberg equilibrium study on human morphogenetic qualities among post-graduate students of Yogi Vemana University, Kadapa, Andhra Pradesh

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Abstract

A population's genotypic frequencies and allelic distribution can be studied using Hardy- Weinberg's equilibrium. This research was done to assess the allelic and genotopic frequencies of post-graduate students at Yogi Vemana University in Kadapa, Andhra Pradesh, India for 15 qualitative morphogenetic traits. This study involved 440 students in total and the frequency order of the blood group was O>B>A>AB in the whole sampled population as well as in both male and female students. In the entire population, Rh-positive (96.1%) was more noticeable than Rh-negative (3.9%). Tongue rolling ability was higher in males (82.02%) than females (59.9%). Tongue folding ability was also higher in both females (89.3%) and males (87.6%). Polydactyly was absent in 94.7% of the sampled population. The prevalence of single-jointed Hitchhiker's thumb was in 67.3% of the tested population. The absence of a bent little finger was in 83.4% of the sample compared to a straight little finger. The presence of curved hairline was observed in window's peak 55% more than the widow's peak (45%). The occurrence of a round chin was more prevalent (79.3%) than a cleft chin and higher in females (82.6%) than males (77.09%). The absence of dimples on the cheeks (81.5%) was more prevalent in the population. The presence of mid-phalangeal hair was more in males (66%) than females (58%). The expression of free earlobe (80.7%), right arm crossing over left arm (85.5%), right-handedness (95.4%) and arched foot (87.5%) was more common in the whole population. In the whole population and male population, all the traits were significant while only the dimpled cheeks in female population were non-significant i.e., only alleles for dimpled cheeks were in equilibrium in the female population and follow the Mendelian ratio in the population of students.

Key words : Allelic frequency, Hardy-Weinberg equilibrium, Morphogenetic traits; Autosomal inheritance.

A population is a collection of individuals from the same species that coexist in a certain habitat, influence one another, and mate to produce fertile offspring[16]. Population genetics is the study of how genes and alleles spread within a population. It also focuses on the examination of evolutionary shifts within and among ethnic groups[15,25]. Understanding population genetics is based on Mendel's law of segregation and independent assortment. The link between the gene and genotype frequencies, both within and across the generations, under assumptions of no migration, no mutation, no selection, random mating and infinite population size was first established by a British mathematician, G.H. Hardy and a German physician, W. Weinberg in 1908 independently and was universally acknowledged as Hardy-Weinberg equilibrium (HWE) or HW principle. This idea was considered to be a useful tool for study in both population genetics and quantitative genetics[8,16]. In an infinitely large population, Hardy-Weinberg equilibrium (HWE) is the genotypic frequency of two alleles of one autosomal gene locus after one isolated generation of random mating: if the alleles are A and a with frequencies p and q (=1- p), then the equilibrium gene frequencies are just p and q, and the equilibrium genotypic frequencies for AA, Aa, and aa are p2, 2pq, and q2 [5,18]. There are observable morphogenetic features that vary in expression among populations and are inherited from parents in an autosomal dominant or recessive way. The HW principle can be used to assess the genotypic and gene frequencies of these features[19]. About 440 randomly chosen postgraduate students from the University were observed to assess fifteen morphogenetic traits, including blood types, the Rh blood group, tongue rolling, tongue folding, polydactyly, Hitchhiker's thumb, bent little finger, widow's peak, cleft chin, dimpled cheeks, mid-phalangeal hair, earlobe attachment, crossing of arms, right handedness, and arched foot. Human blood groups considered as genetic indicators evolved several billion years ago[14]. The ABO blood group system was developed by Karl Landsteiner, who also found the three different types of A, B, and O blood groups as well as the fourth, extremely rare "AB" blood group. In 1930, he was given the Nobel Prize for this work. The ABO glycosyltransferase gene, located on Chromosome 9 (9q34.1), defines the human ABO blood type. The ABO locus, which produces its glycoprotein (antigen) and has three primary allelic variants (A, B, and O), is a classic example of multiple alleles, with A and B co-dominant over O[10,23]. Their blood types and the glycoproteins (antigens) on their blood cells are both determined by the combination of alleles they acquired from their parents. Alleles D and d on chromosome

1 control the Rhesus (Rh) factor, which has two phenotypes: positive (with antigen D) and negative (without antigen D). Both the ABO blood type and Rh factor shows antigenic property on the surface of the red blood cells (RBC)[3]. Tongue rolling is the tendency to turn up the edges of the tongue, which is controlled by a single dominant gene[17]. The ability to fold the tip of the tongue is due to a single dominant gene[17,24]. Polydactyly is a condition that causes an individual to have extra fingers or toes. It is caused by the dominant allele of a gene[31]. The straight thumb takes precedence over the Hitchhiker's thumb (curved thumb). When viewed from the side, straight thumbs appear nearly straight and may have a slight arch. Little fingers can be straight or bent. A bent little finger is caused by a facial expression. The expression of the dominant allele of the hairline gene causes widow's peak or the mid-digital hairline, whereas the expression of a recessive allele causes a straight hairline[34]. Cleft chin is a dimple on the chin caused by the expression of the dominant gene, whereas the recessive genotype is a round chin with no cleft[35]. Due to a single dominant gene, dimple cheeks have round depressions in them[24,33]. The presence of hair on the back of the middle segment of the finger, excluding the thumb, is due to the expression of a dominant gene, whereas its absence is due to the expression of a recessive gene[37]. Earlobe attachments come with or without a connection. A recessive gene causes the attached ear lobe to express, whereas a dominant allele causes the free ear lobe to express[13,36]. Crossing your arms occurs when your arms are folded over your chest with your left arm on top and your right arm on top. The left arm is dominant, while the right arm is recessive[38]. The dominant gene, which is inherited by most people, causes right-handedness, while the recessive gene, which causes left-handedness, causes this feature. Due to the expression of a dominant allele, the arched foot has an arch (clear curve along the inside of the foot) and a band that is slightly less than half the width of the foot connecting the heel and toe, whereas the flat foot allele is recessive and manifests as a change in foot shape where the foot does not have a typical arch when standing. There is diversity and variance among populations as a result of the inheritance and expression of these features. The goal of the current study was to identify the genotypic frequency, distribution, and inheritance pattern of fifteen morphogenetic features.

A total of 440 students of Yogi Vemana University in Kadapa, Andhra Pradesh, India consisting of 178 males (40.45%) and 262 female students (59.5%) in proportion ranging between the age of 19-30 were selected for the study. The study employed a cross-sectional sampling technique, and none of the sampled respondents had any blood relatives. People who refused to participate in the study were excluded. The information was gathered by morphological observations of the many features represented in Table-1. The following equation is used to determine the frequency of a recessive and dominant allele.

$$\mathbf{q} = \frac{\sqrt{\textbf{recessive individuals}}}{\textbf{Total individuals}}$$

$$\mathbf{p} = \mathbf{1} - \mathbf{q}$$

The chi-square test of goodness of fit at 95% confidence interval was performed to analyse the data by using the following equation:

$$\chi 2 = \frac{(Observed - Expected)2}{Expected}$$

The predicted value of the chi-square test was examined using the Mendelian ratio. The Chi-square test was performed to assess the anticipated value using the Mendelian phenotypic ratio of a diallelic gene for complete dominance (3:1), incomplete dominance (1: 2: 1), and triallelic gene (3: 3: 2: 1). (Table-2).

1) Blood group : Blood grouping is an example of multiple alleles controlled by three alleles; I_A codes for antigen "A," I_B codes for antigen "B," and the I allele does not code for any antigen on the surface of red blood cells. A person with the genotypes $I_AI_{A,}$ I_Ai, $I_BI_{B,}$ I_Bi, I_AI_B, and ii belong to blood groups A, B, AB, and O, respectively.

2) Rh factor : Rh factor is another example of multiple alleles governed by C, D, and E alleles in which the 'D' allele is very crucial for the expression of Rh factor. A person with Rh antigen is considered as Rh+ individual and an absence of Rh antigen is considered as Rh- individual.

3) Tongue rolling : The ability to roll the tongue's lateral edges up into a U shape is governed by a single dominant gene[17,24].

4) Tongue folding : One dominant gene regulates the capacity to fold the tip of the tongue[17,24].

5) Polydactyly : An individual with polydactyly possesses additional fingers or toes. It results from a gene's dominant allele[31].

6) Hitchhiker's thumb: Both straight and curled thumbs (Hitchhiker's thumb) are possible. The dominant thumb is curved, not straight. When viewed from the side, straight thumbs appear to be almost straight lines and may contain a small arch.

7) Bent little finger : Little finger can be straight or bent. A bent little finger occurs due to the expression of a dominant allele where the end joint of the little finger of each hand is bent inwards.

8) Widow's peak: A straight hairline results from the expression of a recessive allele of the hairline gene, whereas a widow's peak or the mid-digital hairline is caused by the development of a dominant allele of the hairline gene[34].

9) Cleft Chin : A cleft is a dimple on the chin which is expressed due to a dominant gene while the recessive genotype presents without a cleft or round chin[35].

10) Dimple cheeks : Dimples are round depressions in the cheeks or clefts which are expressed due to a single dominant gene[24,33].

11) Mid-phalangeal hair : The presence of hair on the back of the middle segment of the finger, excluding the thumb is expressed by the dominant gene and its absence is due to the expression of a recessive gene[18].

12) Earlobe attachment : Ear lobes can be detached or free. When compared to the free ear lobe, the connected ear lobe is expressed by a recessive gene and the free ear lobe by a dominant allele[13,36].

13) Crossing of arms: Arms folded

across the chest, with the left arm placed on top is the dominant characteristic while the right arm positioned on the top is the recessive characteristics[9,38].

14) Right handedness : Right-handedness is inherited by the dominant gene and majority of the people show this trait and the gene for the left hand is recessive[38].

15) Arched foot : While the allele for the flat foot is recessive and manifests as a change in foot shape in which the foot does not have a normal arch when standing, the presence of an arch, defined as a distinct curve along the inside of the foot with a band slightly less than half the width of the foot connecting the heel and toe, is due to the expression of a dominant allele.

The statistical analyses were carried out using MS-Excel and IBM SPSS software.

The frequency of blood group 'O' (42.5%) was most frequently detected in the sampled population followed by blood group 'B' with frequency (32.5%), group 'A' with frequency (18.4%) and blood group 'AB' with the lowest frequency (6.6%). The ABO percentage frequencies are ordered O>B>A>AB, and both males and females showed the same pattern. The results of the present study are in correlation with the studies of Rehman *et al.*[26] and Ahmed[2] but vary with the previous studies of Rehman *et al.*, Chandra and Gupta, Usha *et al.*, Dewan *et al.*, Devi and Vankara[7,11,12,25,32]. Rh-positive phenotypes are more common (96.1%) than Rh-negative phenotypes, which are less common (3.86%). Males (99.4%) have a higher percentage of the Rh-positive phenotype than females (93.8%). In the current study and Chandra and Gupta[7] investigations, the presence of the Rh (D) antigen was more common in India than it was in Pakistan (86.02%)[25]. The combined analysis of ABO and Rh factor revealed that O+ had a high prevalence and A- had a low prevalence (O+ > B+ > A+ > AB+ > O- > B- > AB- > A-), which is different from the studies of Rehman *et al.*[27] and more similar to Butt *et al.*[6]. The outcome for one blood type in the entire population, including males and females, deviates greatly from the expected frequencies. This shows that Hardy-Weinberg equilibrium violates the presumptions made. There were more tongue rollers (68.8%) in the sampled population than non-rollers (31.1%). Males (82%) showed more tongue rolling ability than females (59.9%). Similarly, there were more tongue folders (88.6%) than non-folders (11.3%) with a higher percentage in females (89.3%) than males (87.6%). The present study is in correlation with the studies of Razzaq *et al.*[24] and Devi and Vankara[11]. Since polydactyly is a congenital malformation, it is avoided in the population and about 94.7% of the sampled population showed the absence of polydactyly which is in agreement with the results of Roberts *et al.*[28]. The absence of polydactyly was more in males (98.3%) than in females (92.3%). The appearance of Hitchhiker's thumb in the population was 67.2% is more in females (77.4%) than males (52.2%) which are in concurrence with the reports of Munir *et al.*[20]. It was observed that the frequency of straight little fingers (83.4%) in the population was more than a bent little finger (16.5%). The straight little finger was more in males (86.5%) than females (81.3%) which are in concurrence with the study of

Ordu and Nwosu[22]. The frequency of widow's peak was only 45% while the remaining 55% showed straight hairline. Only, 20.7% of the sampled population showed cleft chin while the remaining showed round chin (79.3%) with higher frequency in males (82.5%) than females (77.09%). Only, 18.4% of the sampled population showed dimpled cheeks while the remaining 81.5% showed normal cheeks which correlate with the studies of Anibor[4]. Only, 62.9% of the sampled population showed mid-phalangeal hair on the fingers is with higher frequency in females (66%) than males (58.4%) which correlates with the study of Aboagye *et al.*[1]. In the sampled population, persons with free earlobes (80.6%) are more when compared to attached earlobes. Free earlobes (80.6%) are more common in males when compared to females (79.3%). The present study is in correlation with the studies of Rehman *et al.*[25], Sharma *et al.*[29] and Ordu *et al.*[21] who found the occurrence of free lobes in the population. The right over the left crossing of arms (85.5%) was more common in the population with more frequency in females (86.6%) than males (83.7%). Right handedness is more (85.5%) in the population than left handedness with higher frequency in females (96.9%) than males (93.2%) which is in concurrence with the study of Singh and Sengupta[30]. In the population, 87.5% of the students showed arched foot with higher frequency in females (88.2%) than in males (86.5%) (Table-3). The findings indicated that every one of the fifteen morphogenetic features is important for both the entire population and the male population, indicating that the population is not in equilibrium based on the Mendelian ratio and that at least one of the hypotheses of HW equilibrium is violated (Tables-4 & 5). Only, dimpled cheeks in the female population were not significant and are in HW equilibrium while the remaining fourteen traits are significant and are not in HW equilibrium (Table-6). India is a diversified country with many ethnic groups, races and religions. The students in the present study are from the Rayalaseema region of Andhra Pradesh in Southern India. This region shows some variations within the student population. All the examined morphogenetic traits except dimpled cheeks showed significant results within the student population.

The results of this study showed that only the dominant traits of tongue rolling and earlobe attachment were observed more frequently than their recessive counterparts in the evaluated population of students. Recessive traits included polydactyly, Hitchhiker's thumb, widow's peak, cleft chin, dimpled cheeks, mid-phalangeal hair, and bent little finger. A clear indication of the relationship between morphogenetic traits in the Rayalaseema region of Andhra Pradesh in Southern India was provided by associations of traits studied in the heterogeneous population of students, despite the fact that the results from this study were not typed to ethnicity or group. The findings of this study may therefore be relevant to anthropological, medicolegal, and population diversity investigations in the Rayalaseema student population.

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Table-1. Morphogenetic traits observed in the sampled individuals (n=440)

Sl. No.	Characters	Traits (Phenotypes)	Gene action
1.	Blood group	A, B, AB, O	A and B are codominant while both are dominant over O
2.	Rh Factor	Positive and Negative	Rh positive is dominant over Rh negative
3.	Tongue rolling	Present (+ve) or Absent (-ve)	Tongue rolling is dominant over Non-rolling
4.	Tongue folding	Present (+ve) or Absent (-ve)	Tongue folding is dominant over Non-folding
5.	Polydactyly	Present (+ve) or Absent (-ve)	Presence is dominant over the absence
6.	Hitchhiker's thumb	Single jointed or Double jointed	Single jointed is dominant over double jointed
7.	Little Finger	Bent or Straight	Bent is dominant over straight
8.	Widow's peak	Curved or straight	Curved is dominant over straight
9.	Cleft chin	Cleft or round	Cleft is dominant over round
10.	Dimpled cheeks	Present (+ve) or Absent (-ve)	Presence is dominant over the absence
11.	Mid-phalangeal hair	Present (+ve) or Absent (-ve)	Presence is dominant over the absence
12.	Earlobe	Free or attached	Free is dominant over attached
13.	Crossing of arms	Right over left or Left over right	Right over left arm crossing is dominant over left over right
14.	Right handedness	Right handed or Left handed	Right handed is dominant over left handed
15.	Arched foot	Arched or plain	Arched is dominant over plain

Table-2. Expected Mendelian phenotypic ratios of diallelic and triallelic traits in the populations

	Diallelic		
	T	T	
T	TT	Tt	
T	Tt	Tt	
Complete Dominance	TT + Tt : tt 3 : 1		
Incomplete Dominance	TT : Tt : tt 1 : 2 : 1		
		Triallelic	
	A	B	O
A	AA	AB	AO
B	AB	BB	BO
O	AO	BO	OO
AA + AO : BB + BO : AB : O			
3 : 3 : 2 : 1			

Table-3. Percentage of different traits in the sampled population, males and females

Characters	Traits	Populations (%) (n=440)	Males (%) (n=178)	Females (%) (n=262)
Blood group	A	18.4	18.5	18.3
	B	32.5	32.0	32.8
	AB	6.6	9.0	5.0
	O	42.5	40.4	43.9
Rh factors	Rh positive	96.1	99.4	93.8
	Rh negative	3.9	0.6	6.1
Tongue rolling	Rollers	68.8	82.0	59.9
	Non-rollers	31.1	17.9	40.0
Tongue folding	Folders	88.6	87.6	89.3
	Non-folders	11.3	12.3	10.6
Polydactyly	Present	5.2	1.6	7.63
	Absent	94.7	98.3	92.3
Hitchhiker's thumb	Single-jointed	67.3	52.2	77.4
	Double jointed	32.7	47.7	22.5
Bent little finger	Straight	83.4	86.5	81.3
	Bent	16.5	13.4	18.7
Widow's peak	Curved hairline	45	56.1	37.4
	Straight hairline	55	43.8	62.6
Cleft Chin	Cleft	20.7	17.4	22.9
	Round	79.3	82.6	77.1
Dimpled Cheeks	Present	18.4	11.2	23.3
	Absent	81.5	88.7	76.7
Mid-phalangeal hair	Present	62.9	58.4	66.0
	Absent	37.0	41.5	33.9
Ear lobe attachment	Attached	19.3	17.4	20.6
	Free	80.7	82.6	79.4
Crossing of arms	Right over left	85.5	83.7	86.6
	Left over right	14.5	16.3	13.4
Right handedness	Right	95.4	93.3	96.9
	Left	4.5	6.7	3.1
Arched foot	Arched	87.5	86.5	88.2
	Flat	12.5	13.5	11.8

Table-4. Chi-square analysis and allelic frequency of different morphogenetic traits in the whole population

Characters	Traits	Allele	Allele frequency	χ^2 value, p
Blood group	A	p	0.13	χ^2= 480.4*, p= 0, df=3
	B	q	0.22	
	AB	-	-	
	O	r	0.65	
Rh factors	Rh positive	p	0.80	χ^2= 104.84*, p= 0
	Rh negative	q	0.19	
Tongue rolling	Rollers	p	0.44	χ^2= 8.84* p= 0.003
	Non-rollers	q	0.56	
Tongue folding	Folders	p	0.66	χ^2=43.64* p= 0
	Non-folders	q	0.34	
Polydactyly	Present	p	0.02	χ^2=91.75* p= 0
	Absent	q	0.77	
Hitchhiker's thumb	Single-jointed	p	0.43	χ^2=14.01* p= 0.000181
	Double jointed	q	0.57	
Bent little finger	Straight	p	0.59	χ^2=16.59* p= 0.000046
	Bent	q	0.41	
Widow's peak	Curved hairline	p	0.33	χ^2=93.87* p= 0
	Straight hairline	q	0.67	
Cleft Chin	Cleft	p	0.54	χ^2=4.38* p= 0.036
	Round	q	0.45	
Dimpled Cheeks	Present	p	0.57	χ^2=10.19* p= 0.00141
	Absent	q	0.43	
Mid-phalangeal hair	Present	p	0.39	χ^2=34.05* p= 5.37
	Absent	q	0.61	
Ear lobe attachment	Free	p	0.56	χ^2=7.58* p= 0.0059
	Attached	q	0.43	
Crossing of arms	Right over left	p	0.62	χ^2=25.65* p= 4.09
	Left over right	q	0.38	
Right handedness	Right	p	0.79	χ^2=98.18* p= 0
	Left	q	0.21	
Arched foot	Arched	p	0.65	χ^2=36.67* p= 1.40
	Flat	q	0.35	

'*' indicates 5% level of significance

d.f - Degrees of freedom

Table-5. Chi-square analysis and allelic frequency of different morphogenetic traits in males

Characters	Traits	Allele	Allele frequency	χ^2 value, p
Blood group	A	p	0.15	χ^2 = 161.12* p = 0 d.f = 3
	B	q	0.24	
	AB	-	-	
	O	r	0.63	
Rh factors	Rh positive	p	0.93	χ^2 = 56.7* p = 5.08
	Rh negative	q	0.07	
Tongue rolling	Rollers	p	0.57	χ^2 = 4.68* p= 0.030
	Non-rollers	q	0.42	
Tongue folding	Folders	p	0.65	χ^2= 15.16* p= 0.000098
	Non-folders	q	0.35	
Polydactyly	Present	p	0.13	χ^2= 51.6* p= 6.79
	Absent	q	0.87	
Hitchhiker's thumb	Single-jointed	p	0.31	χ^2= 49.15* p= 2.38
	Double jointed	q	0.69	
Bent little finger	Straight	p	0.63	χ^2= 12.59* p= 0.00039
	Bent	q	0.36	
Widow's peak	Curved hairline	p	0.66	χ^2= 33.62* p= 6.68
	Straight hairline	q	0.34	
Cleft Chin	Round	p	0.58	χ^2= 5.46* p= 0.01944
	cleft	q	0.42	
Dimpled Cheeks	Absent	p	0.65	χ^2= 17.98* p= 0.000022
	Present	q	0.34	
Mid-phalangeal hair	Present	p	0.64	χ^2= 26.07* p= 3.28
	Absent	q	0.36	
Ear lobe attachment	Free	p	0.58	χ^2= 5.46* p= 0.01944
	Attached	q	0.42	
Crossing of arms	Right over left	p	0.59	χ^2= 7.20* p= 0.0072
	Left over right	q	0.40	
Right handedness	Right	p	0.74	χ^2= 31.65* p= 1.84
	Left	q	0.26	
Arched foot	Arched	p	0.63	χ^2= 12.59* p= 0.00038
	Flat	q	0.37	

'*' indicates 5% level of significance

d.f - Degrees of freedom

Table-6: Chi-square analysis and allelic frequency of different morphogenetic traits in females

Characters	Traits	Allele	Allele frequency	χ^2 value
Blood group	A	p	0.12	χ^2= 293.24*
	B	q	0.21	p= 0
	AB	-	-	df=3
	O	r	0.66	
Rh factors	Rh positive	p	0.75	χ^2= 49.8*
	Rh negative	q	0.25	p= 1.63
Tongue rolling	Rollers	p	0.37	χ^2= 31.76*
	Non-rollers	q	0.63	p= 1.74
Tongue folding	Folders	p	0.67	χ^2= 28.62*
	Non-folders	q	0.33	p= 8.77
Polydactyly	Absent	p	0.72	χ^2= 42.14*
	Present	q	0.28	p= 8.48
Hitchhiker's thumb	Single-jointed	p	0.53	χ^2= 0.86*
	Double jointed	q	0.47	p= 0.353
Bent little finger	Straight	p	0.57	χ^2= 5.54*
	Bent	q	0.43	p= 0.018
Widow's peak	Curved hairline	p	0.39	χ^2= 21.5*
	Straight hairline	q	0.61	p= 0.000003
Cleft Chin	Cleft	p	0.52	χ^2= 0.62*
	Round	q	0.48	p= 0.432
Dimpled Cheeks	Present	p	0.52	χ^2= 0.41$^{N.S}$
	Absent	q	0.48	p= 0.52
Mid-phalangeal hair	Present	p	0.42	χ^2= 11.24*
	Absent	q	0.58	p= 0.0008
Ear lobe attachment	Free	p	0.55	χ^2= 2.69*
	Attached	q	0.45	p= 0.1008
Crossing of arms	Right over left	p	0.63	χ^2= 18.94*
	Left over right	q	0.37	p= 0.0000135
Right handedness	Right	p	0.83	χ^2= 67.3*
	Left	q	0.17	p= 2.222
Arched foot	Arched	p	0.66	χ^2= 24.22*
	Flat	q	0.34	p= 8.55

'*' indicates 5% level of significance

$^{N.S}$ Non-significant

d.f- Degrees of freedom

Ethics approval and consent to participate:

All procedures contributing to this work (Proposal No. 01/IEC/VAP/YVU/ZOO./2021-22) comply with the ethical standards of the relevant national guides on the care and use of human sample have been approved and authorized in IEC (Institution of Ethics Committee meeting (Ref. YVU/Dep./IEC/2021, dt. 21/02/2022), Faculty of Life Sciences, Yogi Vemana University, Andhra Pradesh.

Authors' contributions :

The first author, APV designed the concept; information from the human samples was collected by MB and MP. The second and third authors MKA and RK helped in framing the manuscript and correction part. All the authors have read and approved the manuscript.

Consent for publication :

The authors gave consent for publication in the journal.

Availability of data and material :

The raw data used to support the findings of this study are available from the corresponding author upon reasonable request.

Competing interests :

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