

A Comparison of Morphometric Features of Scalp Hair among Different Regions of India

Diya Sajan John, Prathiksha R. S., Sumha Tehreem,
Jinson Jacob, Sarath A. S. & Jeremiah Justus M*

Department of Life Sciences, Kristu Jayanti College (Autonomous), Bengaluru, Karnataka, India-560077

ABSTRACT

Hair is a protein filament that grows out of the follicles of mammalian dermis. Hair is made of a tough protein called keratin and a colouring protein called melanin. Hair is also one of the most common biological evidence found at a crime scene and it is accounted as a class evidence. We can easily use hair to solve the question of who committed the crime as hair helps in individualising a person. From the root of the hair we can get nuclear DNA (Deoxyribose nucleic acid) and from the shaft of the hair we can get mitochondrial DNA. We can also use hair to find out the race and individualistic characteristics of persons. In this study, an effort has been made to distinguish between the morphometric features of hair from the different regions of India. To do this, India was divided into six regions that included the north, south, west, east, central and northeast. Fifty hair samples from each region were collected and morphological and metric features were estimated and compared. This study was conducted as there is a lack of region specific characteristics to identify people of different regions of India through hair.

KEY WORDS: Forensic Science, Forensic Biology, Hair analysis, Forensic hair evidence, Forensic trichology, Hair database, Hair evidence India

Article History | Received: 29. 08. 2022; Revised: 10. 10. 2022; Accepted: 11. 10. 2022; Published Online: 23. 12. 2022

INTRODUCTION

Hair is one of the most common pieces of evidence found at a scene of crime which helps in knowing whether a crime has taken place and also can point to the perpetrator of the crime. Hair is useful as an evidence as it gives us information about the race of an individual, sex of an individual to some extent. Hair evidence can also show from which body part it has been taken from. It also gives us genetic information through DNA.

Hair is a structured protein filament that is composed primarily of keratin and melanin proteins. Hair grows from the follicles found in the dermis. It can be defined as slender outgrowths of the skin of mammals. Hair is one of the traits of mammals. Hair is generally made of two distinct parts: the hair follicle and the hair shaft. The hair follicle is the part that is under the skin and the hair shaft is the part that is not attached to the follicle and this part is exposed at the skin's surface (*Deedrick D et al, 2004*).

The hair shaft is composed of different layers - the cuticle, medulla and cortex. The cuticle is the outermost layer of the hair and is protective in nature, and it is connected to the internal root sheath. The medulla is the innermost region of the hair and can be fragmented, continuous or discontinuous. The cortex is present between the cuticle and medulla of the hair shaft (*Figure 1*).

The hair growth cycle takes place in four phases: The first phase is called Anagen which is the growing phase, the second phase is called Catagen which is the transition phase, the third phase Telogen which is the resting phase and the fourth phase is called Exogen which is the shedding phase.

Hair is found on different parts of our body. These can be found as head hair, pubic hair, facial hair, limb hair, axillary etc. The general morphology of hair can determine the origin of hair.

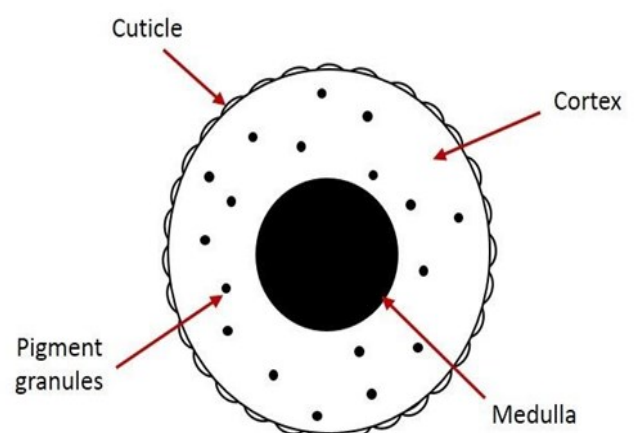


Figure 1: Diagrammatic representation of medulla, cortex and cuticle

Hair from different parts of the body can be determined by length, shape, size, color, stiffness, curliness, pigmentation, medullary appearance and microscopic appearance. Hair is encountered as biological evidence from the crime scene. It can provide various information such as the race, occupation, genetic information etc. While it is possible to retain DNA information from hair evidence, it is avoided due to the cost involved and the availability of equally significant analytic techniques. Morphological examination and a few metric parameters have enough evidentiary value in criminal offences and is preferred in some developing countries.

In India, being a large nation with respect to area and the prevalence of multi-ethnic groups predominantly residing in different clusters there is scope of differentiation of people of different regions using morpho-metric parameters of hair. In the past there have been successful attempts in different regions of south east Asia to differentiate regions based on morpho-metric parameters of hair.

Lee et al 2019, conducted a preliminary study to discriminate ethnic Malay and ethnic Chinese in Malaysia using different morpho-metric features of hair. In this study, differences between two ethnic groups in Malaysia – Malays and Chinese have been assessed using the morphometry of hair. The sample group was composed of 100 Malaysians, 50 each having an equal number of males and females from ethnic Malays and ethnic Chinese. The hair width, scale layer difference, medullary index of each hair were determined using a compound microscope. The inter-variations are found to be statistically important (Lee LC et al, 2019).

Leerunyakul et al 2019, aimed to evaluate hair density and hair diameter of the Thai population at different scalp locations and determine the effect of sex and aging and also to examine the results with those in groups of different ethnicities. A total of two-hundred and thirty nine subjects participated in this study, of which 70 of them were male 160 of them were female. The density of hair and the diameter of the hair was analyzed at four different scalp regions using a quantitative trichoscopic analysis. The highest hair density in Thais was observed in the vertex site. Hair densities at four different scalp regions were considerably different from one another; only hair density at the vertex site showed no considerable difference from that in the occipital area. In contrast, hair diameter did not show any statistically important differences for the different location. Comparing their study with a previous study in other ethnicities, the hair densities in Asians are found to be generally lower, while hair diameter remained consistent (Leerunyakul K et al, 2020).

Chauhan et al 2018, attempted to determine the presence of medulla among the young Jaat residents of western UP among the age group of 20-25 years. Hair samples were collected from different villages of UP from the age group of 20-25 years keeping in mind that this is the age wherein many get involved in different crimes. A total of

100 samples, that is 50 males and 50 females were collected. They found that medulla was absent in a higher number of samples (61.80%). This study highlighted the difference in hair morphology among the population in diverse cultures (Chauhan A et al, 2009).

Moorthy et al 2015, aimed at studying the difference in the hair morphological features such as inner cuticle margin, cuticle thickness and medulla pattern between the dominant races in Malaysia - Chinese, Malay and Indians. Total of 180 hair samples of head hair was collected and a 1cm length part was cut and mounted in a microscopic glass slide and observed under the microscope under different magnifications (40X, 100X and 400X). In the results of inner cuticle margin it was found that twenty five samples in Malay males showed distinct margin, three samples were distinct and two samples were of varied inner cuticle margin. However, in the samples of Chinese and Indians, the male samples showed similar results in all three types. In cuticle thickness, the findings were either thick or thin. The frequency of males in different races more often having thick cuticles was found to be 41.3% in Chinese, 33.3% in Malays and 15.5% in Indians. Frequency of females of different races more often having thick cuticles was found to be 47.8% in Chinese, 35.4% in Malays and 20% in Indians. Whereas the frequency of either genders in the same races having thin cuticles were found to be similar. Continuous medulla patterns in males were found to be as follows - Malays (25), Chinese(10) and Indians (8). Continuous medulla pattern in females was - Malays (24), Chinese (9) and Indians (11). In a fragmented pattern, the frequencies in both the genders were as follows - Chinese has more often, then Indians and finally Malays. In the end, it was found that there were significant differences in hair morphology among the three different races (Moorthy TN et al, 2015).

Tripathi et al 2014, collected 30 scalp hair samples from four regions of India - North, South, East and West. The mean value of the cortex and the medulla diameter was taken for each region in which it was calculated separately for male and female. And finally a ratio of cortex:medulla was calculated for males and females separately for each region and the data was compared. The results showed that cortex:medulla ratio for female students belonging to Manipur is highest, and lowest for females in Meghalaya. The males of Bikaner have the highest mean cortex diameter and lowest in females belonging to the same state. The cortex:medulla ratio is the highest for females in Bikaner amongst the western region. The mean cortex value is lowest in Agra males and highest in Lucknow males in the northern region. Finally, males in Kochi have the highest mean cortex value and females in Bangalore have the highest mean medulla value (Tripathi J et al, 2014).

Singh et al 2018, collected and analysed hair from five different states in India (Uttar Pradesh, Kerala, Bengal,

Jharkhan, and Nagaland) for morphological features such as medulla, inner cuticle margin, cuticle thickness and scaling pattern in order to understand the similarities and differences between these features between all the 5 states. 200 total samples were collected in which 20 males and 20 females were collected from each state. Inner cuticle margin of males - the maximum number of distinct inner cuticle margin was observed in Kerala and Jharkhand males, indistinct feature was maximum in Uttar Pradesh, and variance was maximum in West Bengal. Inner cuticle of females - distinct was found maximum in Kerala and Jharkhand, indistinct was found more in Uttar Pradesh and finally varied inner cuticle margin was found mostly in West Bengal. Maximum thick cuticle in males was seen in Jharkhand, thin cuticle mostly seen in Uttar Pradesh (*Singh D et al, 2009*).

Kaur et al 2000, attempted to differentiate the medulla types among the Brahmins and the Rajputs (two endogamous practising gotra exogamy) of the Punjab, India. Scalp hair samples from two hundred Punjabis belonging to the two caste groups (100 each) were collected. The age of suspects ranged from 10-70 years. The findings show that the Brahmin and Rajputs have differences in the frequencies of continuous, discontinuous, fragmented and absent type of medulla (*Kaur G et al, 2000*).

Essel et al 2019, attempted to identify the effect on hair by the hair treatment methods employed by Ghanaian women. Chemical treatments of natural negroid hair break disulphide bonds that give hair its strength, thereby weakening it and affecting the gross appearance. For this study 96 indigenous Ghanaian females volunteered, they were aged between 14-55 years. 32 participants for each type (Afro(unstyled), styled (braids), not chemically treated) were taken. These hair strands were then cleaned using 5% alcohol for 35 min and then dried. They found that chemically styled hair has the widest shaft diameter. The medullary index increased from chemically relaxed, naturally styled to Afro hair. They concluded that medulla was the thickest in Afro hair which showed its correlation with shaft diameter in conformity (*Essel EA et al, 2019*).

AIM OF THE STUDY

To examine and compare morphometric features of scalp hair among the different regions of India, and to initiate a process of identifying region based on hair evidence.

SAMPLE

Hair samples were collected from 6 six different regions which encompass entire India. The age group of samples ranged from 17 - 35. The subject was first approached and a rapport was established. The subject was made to sit in a comfortable position. Two strands of scalp hair from the middle section of the head were plucked, ensuring that the root was present and then packaged in a drug-gist fold. The details of the individual were written on the druggist fold (name, age, sex and state).

According to the zonal map of India, India is divided into six zones as - North zone, South zone, Central zone, North East zone, East zone and West zone. Each zone has a specific number of states and union territories. North zone consists of five states (Jammu & Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Uttar Pradesh and Haryana). The South zone consists of four states (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu). The central zone contains two zones (Madhya Pradesh, Chhattisgarh). North east contains eight states (Assam, Sikkim, Nagaland, Meghalaya, Manipur, Mizoram, Tripura, and Arunachal Pradesh). East zone contains four states (Bihar, Orissa, Jharkhand and West Bengal). West zone consists of four states (Rajasthan, Gujarat, Goa and Maharashtra). 50 samples were collected from each zone /region for the purpose of this study (*Table 1*).

Table 1- The sample distribution among the different regions of India

Region	Sample collected	Number of males	Number of females
South	50	28	22
North	50	22	27
East	50	25	25
West	50	14	34
North East	50	23	27
Central	50	19	31

METHODOLOGY

1. The hair length was measured in millimetres.
2. The hair was taped at both the ends on a glass slide and was observed under a compound microscope under 10X magnification for the need for decolourization.
3. The hair strand which did not require decolourization was directly examined under a compound microscope in 40X magnification.
4. The hair which needed to be decolourized was put in a mixture of 1:1 of Ammonia and Hydrogen Peroxide in a petri dish for 20 minutes or until the hair turns a lighter shade of brown.
5. After decolourization, the hair was pat dried using a filter paper and observed under a compound microscope fitted with a micrometre in 40X magnification.
6. The characteristics observed for were - hair root diameter, hair width & medullary width in proximal end,

distal end and mid region.

7. The medullary index was then calculated using the formula - Medullary width / Total width of hair at proximal end, distal end and mid region.

All the findings were documented and analysed.

FINDINGS

The data collected from analyzing all the samples was compiled into a sheet and the mean value of each of the parameters was calculated for each region and the resulting values were compared with each other.

The following tables 2 - 4 show the collected data under different headers.

Table 2 - Variation in hair length among different regions

Region	Hair length in mms	
	Female	Male
North	365.85	78.73
East	328.64	91.92
West	327.71	80.93
South	366.18	66.11
North East	360.78	86.83
Central	264.10	58.00
Mean	335.54	77.08
SD	35.84	11.67

Table 3 - Variation in hair width and medullary index among different regions
 Legend: TD - Total diameter; MD - Medullary diameter; MI - Medullary index

Region	Proximal region			Mid-region			Distal region		
	TD	MD	MI	TD	MD	MI	TD	MD	MI
North	33.34	5.07	0.15	34.62	4.93	0.14	35.40	5.13	0.14
East	32.74	4.98	0.15	33.12	4.91	0.14	33.60	4.77	0.14
West	33.22	4.55	0.14	33.78	4.75	0.14	33.44	4.47	0.13
South	32.02	5.51	0.17	33.62	5.19	0.15	31.90	5.00	0.15
North East	35.60	5.21	0.14	36.36	5.36	0.15	36.26	5.06	0.14
Central	32.84	4.73	0.14	31.46	4.83	0.15	29.58	5.00	0.17
Mean	33.29	5.01	0.15	33.83	5.00	0.15	33.36	4.90	0.15
SD	1.12	0.31	0.01	1.48	0.21	0.01	2.20	0.23	0.01

Table 4 - Variation in hair root diameter and need for decolourisation among different regions

Region	Hair root diameter	Number of samples /50 which required decolourisation
North	56.47	210
East	53.34	11
West	52.32	10
South	53.16	42
North East	53.98	13
Central	53.83	18
Mean	53.85	19.17
SD	1.29	10.92

SIGNIFICANT FINDINGS

In figure 2, it can be observed that the hair root diameter of people in India vary among regions. People in the North region have the largest root diameter and the people in West region have the smallest root diameter with a considerable variation among all regions.

Figure 3 explains how the need for decolourisation of hair samples among different regions in India is variable. People living in the South region have a remarkably higher pigmentation in hair compared to other regions. The other regions possess moderately variable need for decolourisation.

Figure 4 depicts the mean lengths of hair among the different regions. Even though hair length is dependent on many factors including grooming, in India women tend to have lesser inclination towards shortening of hair. In Central India the hair length among women seems to be significantly shorter than the rest of the regions. While the hair length among other regions and especially among male it is quite similar which is an expected feature.

With regard to hair width figure 5 depicts that the North region shows highest value of mean hair diameter in distal region, East region shows highest value of mean hair diameter in distal region, West region shows highest value of mean hair diameter in intermediate region, South region shows highest value of mean hair diameter in intermediate region, Northeast region shows highest value of mean hair diameter in intermediate region, and Central

region shows highest value of mean hair diameter in proximal region. It can also be observed that the mean hair diameter value of Northeast region is highest in proximal, intermediate and distal regions compared to the other regions. And there is a significant difference in the value of the central region in the distal part compared to the other regions.

With respect to hair root diameter, as shown in figure 6, the south region shows higher value of hair root diameter for male population and northeast shows higher value of hair root diameter for female population. It was seen that the Central region showed the lowest value of hair root diameter for male population and the south region showed the lowest value of hair root diameter for the female population. It was observed that the average hair root diameter was higher in male population compared to that of the female population.

DISCUSSION

The objectives of the study were to identify if there are any differences in the morphometric features of hair among the regions, if we can individualise a particular region based on the morphometric characteristics and establish a process of identification of people and which zone they belong to in India.

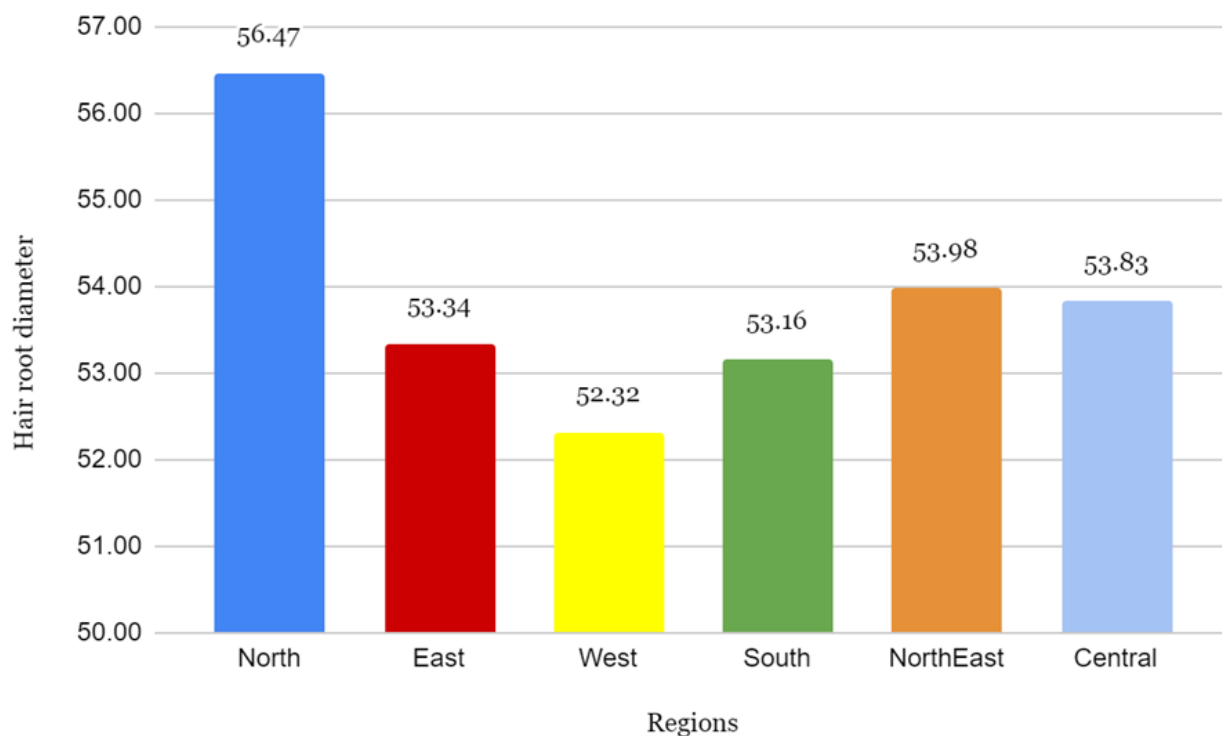


Figure 2 - Graph showing the mean value of hair root diameter among different regions

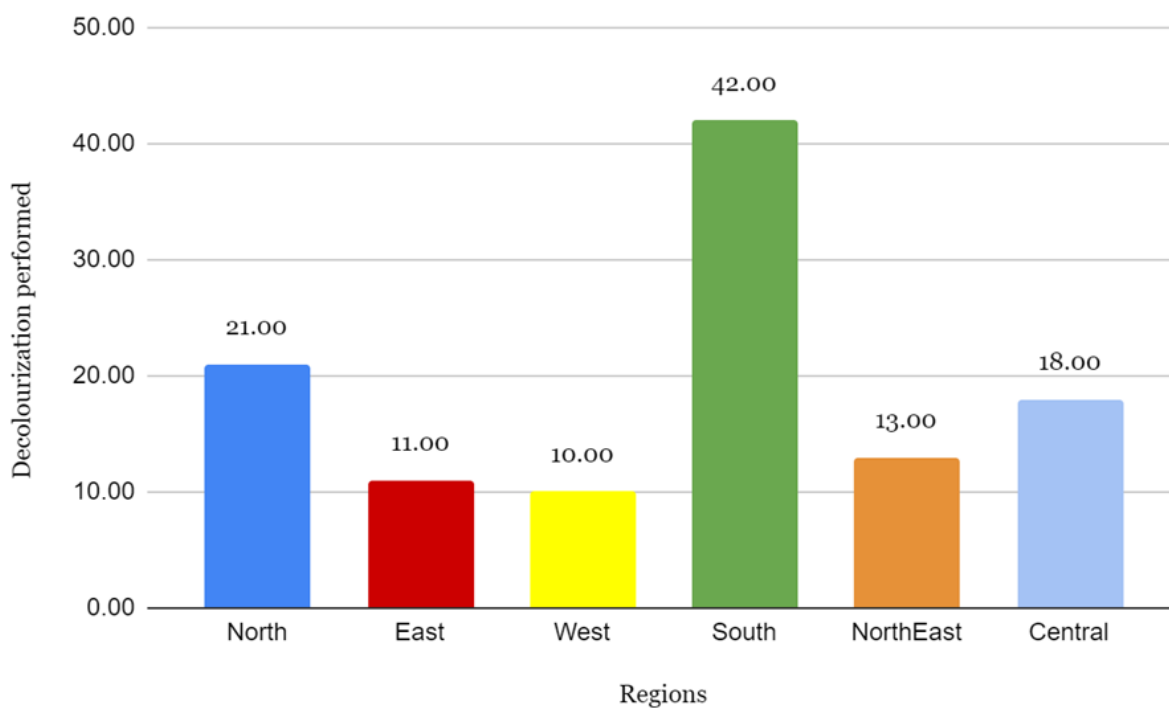


Figure 3 - Graph showing the value of need for decolourization among different regions

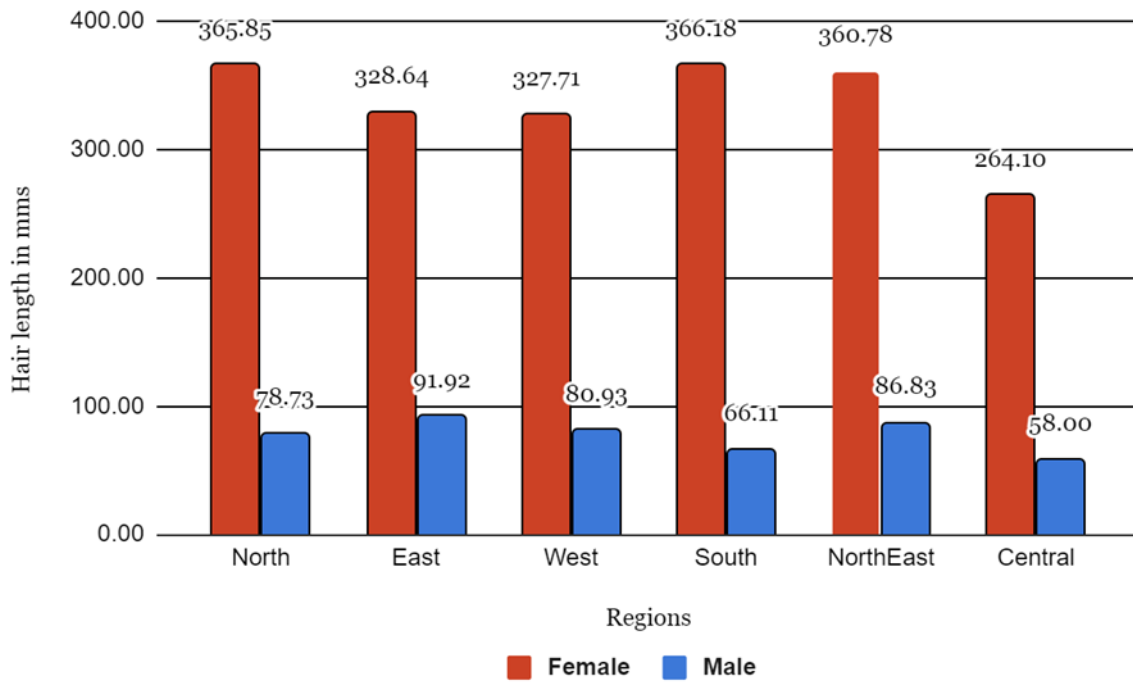


Figure 4 - Graph showing average hair length among males and females in different regions

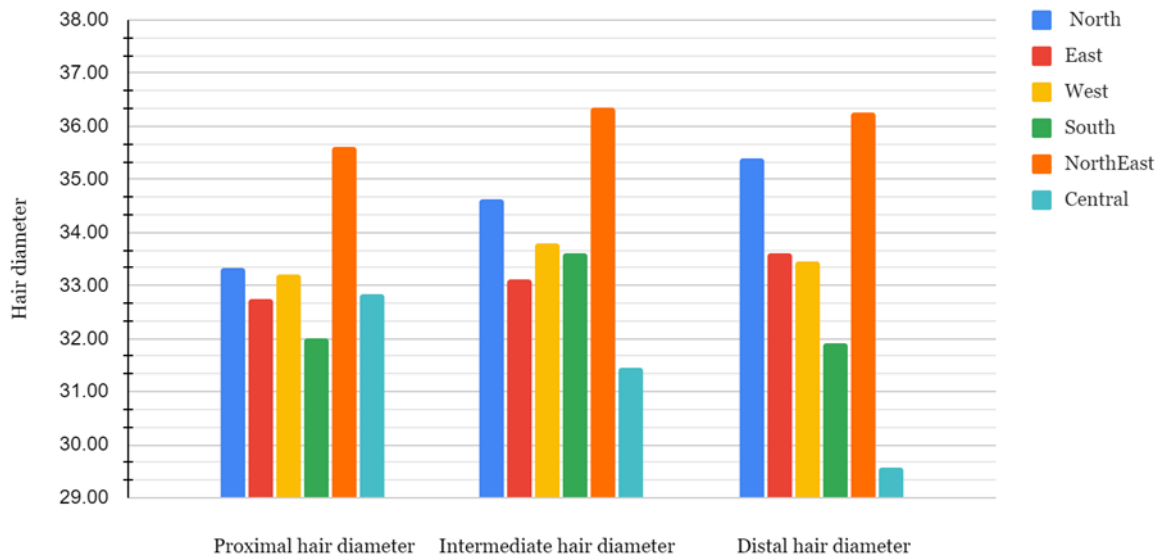


Figure 5 - Graph showing average hair diameter in proximal, intermediate and distal regions of hair among different regions

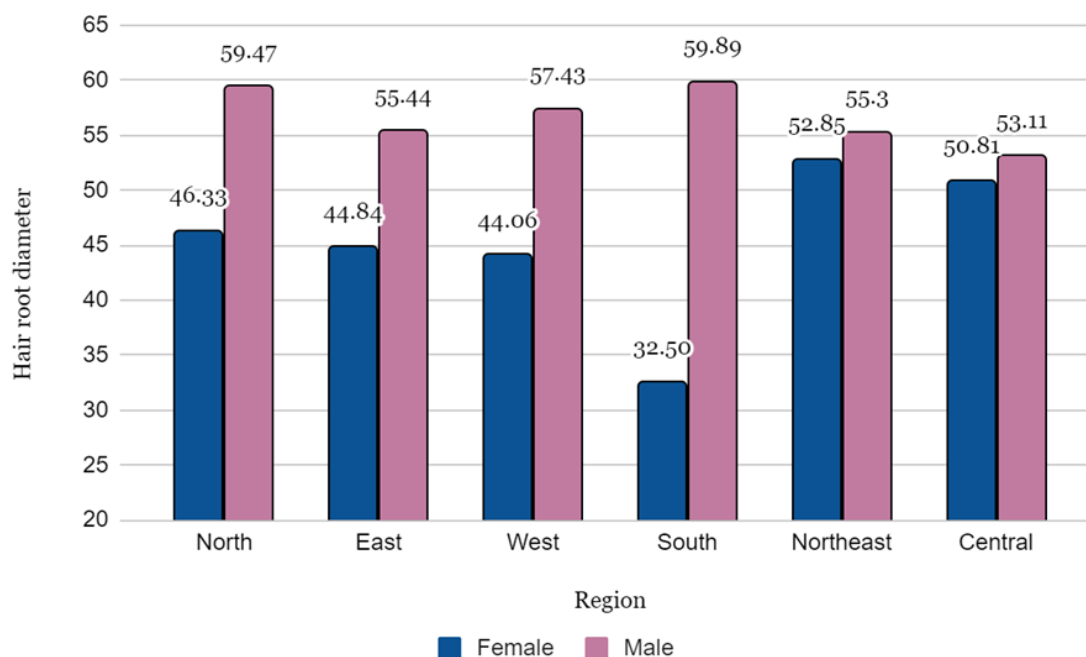


Figure 6 - Graph showing the average hair root diameter in males and females of different regions

The major findings of the present study are

1. The people in the north region have the largest root diameter and people in the west region have the smallest root diameter.
2. A large number of samples require decolorization in the south region
3. The hair of people in the south region contain more pigment compared to all other regions.

There is a similar range between the hair root diameter of females of all the regions and males of all regions respectively.

As discussed above hair is commonly encountered as evidence. Hair's morphological variations are highly useful in many of these crimes where it is encountered as evidence. Routine hair examination is a established process for analysing hair evidence. If the findings of routine hair examination can be expanded to identify the individual based on hair evidence, it could go one step forward in efficiency use of its evidentiary value.

This study attempted to identify region-specific hair morphometric features in India. The results are in consonance with earlier studies and helps to pave a way for morphometry-dependent regional features of hair in India. If expanded, this study holds promise to catalogue further region specific features of hair in India.

REFERENCES

Chauhan A, Tyagi N, Shukla S (2018). *A Study on The Presence of Medulla Types of Hair Among the Young Jaat Residents of Western Uttar Pradesh*. J Forensic Sci. 10 (4): 555795 .

Deedrick D, Koch S (2004). *Microscopy of Hair Part 1: A Practical Guide and Manual for Human Hairs*. Forensic Sci. Commun. 6 (1).

Essel EA, Ahenkorah J, Blay RM, Adjenti SK, Adutwum -Ofosu KK, Hottor BA, et al (2019). *Microscopic Characteristics Of Scalp Hair Subjected To Cultural Styling Methods In Ghanaian African Females*. Clin Cosmet. Investig. Dermatol. 12:843–50.

Kaur G, Kumar M (2000). *Medulla Types of Hair - A Study of the Brahmin and Rajputs of the Punjab* J Hum Ecol. 11(6):483–6.

Lee LC, Wan Mohamad Fuad WNS, Abdullah SS, Ong KL (2019). *Preliminary study on morphometric analysis of the human scalp hair for discrimination of ethnic Malay and ethnic Chinese in Malaysia*. Egypt J Forensic Sci. 9 (1):31.

Leerunyakul K, Suchonwanit P (2020). *Evaluation of Hair Density and Hair Diameter in the Adult Thai Population Using Quantitative Trichoscopic Analysis*. Bio-Med. Res Int. 10: 1–6.

Singh D, Kesharwani L, Jain AK, Gupta AK (2018). *Comparative Study of Morphological Features of Hair in Five State of India For Forensic Consideration* 1 (2), 12 -21.

Tripathi J, Mishra M, Saran V, Gupta A (2014). *Variation in Morphological Features of Human Head Hair of Different Regions of India*. 2 (8) :5–7.