Journal of Population Therapeutics & Clinical Pharmacology

**RESEARCH ARTICLE**
**DOI:** 10.53555/jptcp.v31i4.5619

# ANTHROPOMETRIC ESTIMATIONS USING HAND DIMENSIONS AMONG THE NORTH INDIAN POPULATION

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**Abstract**
This study delves into the anthropometric dimensions of hands among various North Indian populations, examining differences across socio-demographic and occupational lines. Through a cross-sectional analysis involving a focused sample of 100 individuals, it aims to shed light on the intricate variations in hand measurements and how these differences can be applied in forensic anthropology for identification purposes. The research emphasizes the importance of hand anthropometry in understanding human diversity, sexual dimorphism, and its potential applications in forensic science. Through meticulous measurement and analysis, it provides valuable insights into the ethnic and regional variations within the North Indian context, contributing significantly to the fields of anthropology and forensic identification.

**Keywords:** Anthropometry, North Indian Populations, Hand Dimensions, Forensic Anthropology, Sexual Dimorphism, Socio-Demographic Variations, Occupational Influences, Human Diversity, Ethnic Variations.

## Introduction

### Anthropology

The primary driving force for the development of the field that methodically examines human history, culture, and future from a bio-cultural viewpoint is man's innate curiosity in himself. People have always been curious in the origins of humanity, the distribution of human genetic traits, and the timing and purpose of human emergence on Earth. This vast array of inquiries about people is what anthropology is all about. Anthropology has been the naturalistic method for answering people's inquiries about themselves for the last two centuries. Anthropology is therefore defined as the study of human societies and the insatiable curiosity in human nature, including but not limited to: beliefs,

behaviours, rituals, conventions, and cultural practices. The study of human origins, diversity, nature, adaptability, and evolution is the overarching goal. Time and place are fundamental concepts in this field of research. Physiology, biochemistry, genetics, and dietary history are all part of what makes a human being. However, kinship, family, caste, religion, custom, ritual, ceremony, politics, and language are all part of what makes a human being social. It looks at things from every angle. Numerous facets of the human condition are considered in a comprehensive study. As an example, anthropologists often include the following details when describing a people: their physical environment, the way they organise family life, the language they speak, the patterns of their settlement, their political and economic systems, their religion, and the styles of their art and clothing. In order to gain a better grasp of human culture and other cultures, anthropologists have devised a specific technique they call "field-work." This entails conducting first-hand, systematic explorations of diverse human cultures, and the documentation of these observations is called ethnography. Because of it, anthropology may be considered a science, as it supplies the data needed to construct and evaluate hypotheses. Because it is storing a treasure trove of rich material that has been generated and is being generated by dynamic human endeavour, anthropology has the chance to establish itself as the top science.

**Branches of Anthropology**

The field of anthropology may be broadly classified into four subfields:

**Socio – Cultural Anthropology**

The field known as socio-cultural anthropology focuses on "the study of social behaviour, especially from the point of view of the systematic comparative study of social forms and institutions." Studying man in relation to his cultural and social milieu is the focus. Culture is uniquely human, in contrast to society, which is halted at the subhuman level. It has evolved into a scientific discipline that can explain cultural parallels and differences and characterise the whole spectrum of human conduct. Family, kinship networks, political organisations, legal processes, religious cults, and the relationships between these and other institutionalised forms of social conduct are the primary foci of this academic field. Unlike its early iterations, contemporary socio-cultural anthropology does not restrict its research to "primitive" tribal or "non-literate" societies. At the turn of the twentieth century, it was known as ethnology; however, that name was eventually supplanted by cultural anthropology in the United States and social anthropology in Britain. It delves into the notion of culture, evolution, and diffusion, and how these concepts shed light on the dynamics of change and stability. The field focuses on the study of social structure, which includes the study of civilization and culture. Based on differences in racial/ethnic background, language, culture, and practice, it compared various people and their ways of life. The field also delves into the study of how human social organisations came to be and evolved over time. By actively seeking out opportunities to compare and contrast other cultures, it eliminates the idea of ethnocentrism. Researching contemporary forms of premodern culture, studying cross-cultural exchange and its associated processes, piecing together social history, and discovering generally applicable social laws are the main goals of socio-cultural anthropology. Analysing a society or culture from every angle is fundamental to socio-cultural anthropology.

**Archaeological Anthropology**

By studying artefacts from bygone eras, archaeological anthropologists hope to piece together how people lived and what they valued. Some have compared archaeologists to "private investigators of the nomads" because of their work unearthing cultural artefacts from various strata of soil for the sake of research.

Archaeology is seen as a reflection of human creativity and construction skills. Old World Archaeology, which makes use of textual aids, and New World Archaeology, which does not, are two distinct schools of thought within the field of archaeological anthropology. In contrast to the latter, which focused on the study of ancient civilization and its evolution, the former primarily dealt with archaeological investigations of the historic era. The field of archaeology focuses on the artefacts and

artefact practices that date back to the time before written language emerged, as well as the dissemination of culture throughout that time. Careful, layer-by-layer removal of the numerous traces left behind by unknown peoples is achieved using highly specialised procedures and dated methodologies. With the help of biologists and other scientists, archaeological anthropologists can piece together the natural environment, identify the early food producers and their diverse activities, and draw conclusions about the foods that ancient people consumed from artefacts like pollen and bone that have been buried in dirt, as well as from cave walls that have been blackened by smoke and unusual variations in the soil and stones. By analysing organic elements and charcoal from long-gone fires, archaeologists try to determine the exact geological era when the site was inhabited.

**Linguistic Anthropology**

The field known as "linguistic anthropology" examines language and speech from a sociocultural perspective, spanning both location and time. Emotions and sentiments are communicated via language. This is the most powerful way for people to grasp the ideas that make up human intelligence. A man without language is a cripple. Consequently, the ability to communicate verbally is one of the most distinguishing aspects of human beings and their civilization. "The Word" is very important in Hindu mythology. Anthropologists who specialise in language study how languages develop, change, and convey meaning within specific social and cultural settings. It gets that language is a tool for communication within a civilization and that there are connections between language and culture. The field is centred on the study and development of language. It shows how languages have progressed over time, from dialects spoken locally to those spoken in classical and global contexts. In doing so, it discovers the historical connections between languages and attempts to recreate the history of a specific language, ultimately leading to a knowledge of the universal qualities shared by all human languages. The theory of language's genesis and development is seen by it. It includes the steps involved in learning a language and the many phases of writing. The study of phonemic, syntactic, and morphemic features of many languages is also of importance to it. The laws that govern the development of language are shown by it. For example, it explains how words are formed by combining sounds, and how sentences are formed by combining phrases. The field focuses on analysing real-life speech in different social and environmental settings.

**Physical Anthropology / Biological Anthropology**

A physical anthropologist studies human beings in relation to their physical, social, and cultural environments. This subfield of anthropology places biological and social aspects of man in secondary positions. In it, the similarities and contrasts between the world's many human populations are studied. Research in this area aims to fill gaps in our knowledge about human biology, including our origins, evolution, variation, sexual differences, the distribution of various physical traits across the globe, the causes of disease and premature death, and the ways in which humans adapt to different environments. The field may trace its roots back to a group of individuals including Paul Broca, Charles Darwin, Alfred Russell Wallace, Samuel George Morton, John Frederick Bluemenbach, and Comte De Buffon. Nonetheless, there are essentially three subfields within physical anthropology. Ethology is the study of animal behaviour, whereas Palaeontology is the study of ancient life and Ne-ontology is the study of contemporary life. By piecing together fragments of fossil evidence, physical anthropologists piece together the human evolutionary story, try to put ourselves back in our ancestors' shoes, and figure out how we adapted to our changing circumstances. In the context of real-life primates, it delves into the comparative study of physiology, genetics, anatomy, and other related topics, including human diversity and evolution through racial classification, body type, environmental adaptation, and molecular and population genetics. Therefore, this area of anthropology is highly related to other branches of biology, including genetics, physiology, anatomy, and taxonomy. The primary focus of physical anthropologists is on factual description and data collecting.

**Forensic Science**

According to the Oxford English Dictionary (2005), the term "forensic science" originates from the Latin word "forensics," meaning "before the forum" or, translated, "relating to court of law" or debates and discussions about public law. "The scientific discipline which is directed to the recognition, identification, individualization and evaluation of physical evidences by the application of the principles and methods of the natural sciences for the purpose of administration of criminal justice" is one definition of forensic science. Investigating and establishing facts of interest in connection to criminal or civil law involves the use of a wide range of scientific and technological methods. These days, "forensics" may stand in for "forensic science" as "forensic" is almost synonymous with "legal" or "related to courts," so the substitution is acceptable. A vital aspect of the justice system, forensic science supplies investigators and judges with objective scientific evidence that may be used in legal proceedings (Houck and Siegel, 2009). They prove or disprove the existence of a connection between the crime, the perpetrator, the victim, and the time and location of the crime. One of forensic science's primary roles is to analyse physical evidence retrieved from crime scenes and give scientific data that may be used to positively identify a suspect in medico-legal situations. Medical knowledge's capacity to elucidate questions of law, such as the deceased's identification and the cause of death, is known as medico-legal acumen. The purpose of this is to help determine who you are in the event of a mass calamity or natural disaster, such as a train crash, aeroplane crash, earthquake, bombing, etc.

**Forensic Anthropology**

As a branch of physical anthropology, forensic anthropology focuses on solving crimes. It takes a prominent position, and a subfield that was once a component of physical anthropology has not only differentiated but also grown into its own field. It is one of the most significant subfields of forensic science as it draws both its focus and its topic matter from forensics (Byers, 2005). The field of "anthropology" studies human behaviour, origins, and physical and social evolution, whereas the field of "forensic" refers to the collection of scientific physical evidence for use in legal proceedings. As a result, forensic anthropology is the study of scientific evidence collection and analysis via the application of anthropological knowledge and methods. Put another way, it's the study of human anatomy and physiology as it pertains to the law. Numerous writers have offered their own definitions of forensic anthropology. In addressing the issue of medico-legal jurisprudence, forensic anthropology applies the specialised expertise of physical anthropologists to factors such as sexual orientation, race, age, and extraordinary individual variation (Snow, 1973). The field of physical anthropology that focuses on positively identifying human remains after removing any non-human components is known as forensic anthropology, according to Stewart (1979). It makes an effort to recreate certain people (Krogman and Iscan, 1986).

## 2. Literature Review

Although research on human hands has been going on since ancient times, it is only recently that this area of anthropology is discovering new uses for its anatomical findings. Studies of the human hand have been conducted from a variety of vantage points, both nationally and internationally, as previously mentioned:

In an effort to identify sex among upper Egyptians above the age of 18, Aboul-Hagag et al. (2023) measured the hands of 250 men and 250 girls and compared the lengths of their index and ring fingers. Measurements and calculations were made for the hand's length, breadth, index, index, and ring finer ratio. According to their findings, men typically had longer hands than females, with an average length of 1.3 cm longer. Hand indices of 40.55 or more were thought to indicate males, while those of 40.55 or less indicated females. The index to ring finger ratio was larger in females compared to men; a ratio of less than or equal to 0.976 indicated males, while a ratio greater than 0.976 indicated females.

In a study with 343 males and 290 females, ranging in age from 18 to 42 years, Barut et al. (2023) examined the correlation between hand preference and asymmetry of hand measures. After

controlling for hand preference and sex, the research found no statistically significant difference between the right and left sides of the hand in terms of length, third finger length, palmer length, and digit index value.

Concerning computer-related anxiety and academic achievement in computer science, Brosnan et al. (2023) investigated the 2D: 4D digit ratio. The study's findings imply that both sexes benefit academically and have less computer-related anxiety among individuals who were exposed to greater amounts of testosterone during gestation.

In order to determine the gender of dismembered remains, Kanchan and Krishan (2023) reviewed the literature on anthropometry of the hand. According to the authors, forensic specialists may use anthropometry of the hand to determine sexual dimorphism, which helps with the identification of severed or mutilated limbs. Hand anthropometry's overall importance, accuracy, and reliability in personal identification are also covered in the review.

A sport that demands both cardiovascular efficiency and high power output, rowing ergometer performance was studied by Longman et al. (2023) in relation to the digit ratio (2D: 4D). The study included 77 men and 70 women. The results showed that digit ratio was a good predictor of rowing skill in men but not in women. Researchers concluded that the ability to react to exposure to foetal testosterone differs across the sexes.

A biometric verification and recognition system that uses multi-dimensional hand geometry and can extract 3D and 2D biometric information was introduced by Mathivanan et al. (2022). The suggested method eliminates the need for any kind of touch by taking pictures of the users' hands in three dimensions using a digital camera. Normalising images, extracting features, and matching features are some of the main computational modules. In addition to the unit normal vector and finger surface curvature, the system also included two more representations. Specifically, the suggested three-dimensional hand geometry characteristics record the cross-sectional finger segments' curvature change. Combining 2D and 3D hand geometry characteristics provides highly discriminating information for biometric verification, according to results on a database of 150 photos obtained from 50 participants.

Mestrovic and Ozegic (2022) detailed a phenotypically normal man with a single bilateral inter-digital flexion crease in his fifth finger. A 28-year-old boy from Croatia with a phenotypically normal appearance has one wrinkle between his little finger's two middle fingers. Based on the study's findings, this case is really unusual and warrants additional investigation via karyotyping and genetic testing.

Nigeria, Uko et al. (2022) looked at 134 men and 83 females to determine the frequency and distribution of extra digital flexion creases. Eighteen people took part, and all of them had the extra digital flexion crease in one finger, right or left. Findings also indicated that men are more likely to have them than women, that they are more common on the left than the right hand, and that they are more common on the ring finger of the left hand compared to the middle and index fingers of the right.

Male industrial workers from the Indian state of Haryana, ranging in age from 18 to 62, were the subjects of a research on hand index measurement by Chandra et al. (2021). In order to determine hand index, the length and width of the hands of 1,540 male employees were measured. Male industrial workers were found to have a mesocheir hand index of 45.19, according to the results. There seems to be a substantial disparity in hand anthropometry across male populations worldwide and even between nations, according to the research.

Das and Meshram (2021) developed a biometric identification method that makes effective use of hand shape. Thirty participants, ranging in age from twenty-four to twenty-nine, had their three-dimensional hands scanned in both directions. The images were captured with a standard digital camera and a light source. Feature extraction and matching followed preprocessing. With a modest error rate of around 7% and an attained accuracy of 93%, the findings demonstrated remarkable improvement.

The hand length prints of ninety-three male Ladakhi Buddhists from Kashmir were measured by Kapoor et al. (2021). We assessed height and measured hand length directly and indirectly (from

fingerprints). According to the findings, there is a strong positive relationship between the two variables of height and hand length. This discovery has important implications for anthropology, medicine, and the law since it provides a population-specific regression equation for estimating height.

In a study conducted by Krishan et al. (2021), the researchers in northern India used the index and ring finger to determine sex. Seventy males and seventy girls were among the 140 people that were sought after. To estimate sex, we used a prediction equation derived from binary logistic regression analysis. The findings showed that there are noticeable disparities between the sexes when it comes to the length of the index and ring fingers as well as the ratio of the two.

By using regression models to hand measurements, Laulathaphol et al. (2021) were able to predict Thais' stature. One hundred randomly chosen Thai students, ranging in age from eighteen to twenty-six, had their stature, hand length, hand breadth, and palm length measured. The studies found a favourable and statistically significant relationship between height and hand measures. Additionally, they mentioned that the hand length had the best standard error of estimate (SEE: 3.295 - 3.722 cm) and can be a good indicator of height.

Predicting stature using hand anthropometry, Numan et al. (2021) compared three main ethnic groupings in Nigeria. From the Hausa, Igbo, and Yoruba ethnic backgrounds, there are 407 right-handed dominant people (210 men and 197 females) ranging in age from 18 to 35 years. The findings showed that the men of the three tribes were noticeably taller than the females; the Hausa and the Igbos also had noticeably longer hands than the females of the other two tribes, while the Yorubas were noticeably shorter than the Hausa and the other two tribes. The results of the study corroborated previous research showing that racial and ethnic differences exist in relation to hand factors.

In their work on hand geometry-based personal verification and identification, Saxena et al. (2021) introduced an algorithm for automated hand-based person recognition and a novel thresholding approach for hand-image separation. We used the palm breadth, finger length and width, and other measurements to identify the subject. Users are allowed to position their hands as they choose in the proposed system; the peg is not necessary. From 96 test subjects, we were able to extract 10 left-handed photos. The enrollment method employed five photos from each user, while others were used to evaluate the performance of the suggested algorithm. The verification and identification process included testing and comparing six distinct distance functions. With an identification rate of 97.44% and a verification rate of 98.72%, this method produced the lowest error.

An identification dynamics-stature was computed from palmer prints among the Indian people by Choudhary and Kapoor (2020). The purpose of the study was to draw attention to the importance of palm prints as a form of identification and to propose their potential use by law enforcement and other forensics-related organisations.

The correlation between aggressive driving behaviour and digit ratios as predictors of individual accident participation rate was investigated by Havarneanu et al. (2020). A total of 150 right-handed male drivers had their data analysed for 2D:4D and rel2 ratios. While the 2D:4D digit ratio did not show any link with the number of accidents, the data showed a negative and statistically significant correlation between rel2 and accident count.

Researchers Khadem and Islam (2020) sought to generate anthropometric data for males in Bangladesh ranging in age from fifteen to sixty-four. The findings revealed notable disparities in the proportions of the male population from Bangladesh compared to males from other countries. Males of Bangladeshi descent were found to be between 1.3 and 11.8 centimetres shorter than their European counterparts. The findings were anticipated to be very valuable in developing ergonomic goods for men in Bangladesh.

In a research by Sen et al. (2020), 500 participants (250 men and 250 females) ranging in age from 18 to 60 years were included in the sample to determine the accuracy of height assessment using the lengths of the index and ring fingers. Index and ring finger lengths were positively and strongly linked with height, according to the data. In order to estimate stature, both linear and multiple regression equations were developed; nevertheless, the coefficient of determination for multiple regression models is greater than that of linear regression models.

While Smedley et al. (2020) found no correlation between the 2D: 4D digit ratio and the degree of depression in men, they did find it in females. A total of 128 undergraduates (51 men and 77 females) ranging in age from 18 to 24 took part. In order to determine the 2D: 4D ratio, we photocopied each participant's right hand and measured its length. A greater digit ratio was associated with higher depression ratings in females, according to the data, but not in men.

Jee and Yun (2019) used a sample of 167 men and 154 women from the Korean population to estimate height using a variety of hand anthropometric measures. The length, width, thickness, and circumference of each hand and wrist were among the 29 measures taken. In both sexes, the data revealed that hand length was most correlated with height ($r = 0.534$ vs. 0.628 for men). Nevertheless, the regression equation's major determinants turned out to be palm and hand length. In addition to determining that hand length is the most important predictor of height, the research derives simple and many regression models for reliable prediction of stature.

A research was carried out by Jee et al. (2019) to determine the sex of a Korean population consisting of 167 males and 154 females using different hand measurements. The measurements of the hand included 29 different factors, such as the length, width, thickness, and circumference of the fingers, palm, and wrist. Discriminant analysis confirmed the reliability of sex identification. According to the results, the best accuracy for male sex predictions was 88.6% and for female sex predictions it was 89.6%. Researchers concluded that there was no age or gender effect on hand component dimensions and that the following measurements should be utilised for sex determination: maximum thickness, palm length, hand width, and hand length.

A total of 41 male and female students from Colombian Caribbean College, ranging in age from 16 to 55 years, were subjected to hand anthropometric characterization by Massiris et al. (2019). A software-based computer tool was created and tested with the old manual approach to measure a total of 25 hand measurements. The findings demonstrated that the measured hands inside the nation and outside were diverse and varied in their characteristics.

Paulis (2019) used handprint measurements to assess stature in the Egyptian population. We used a software programme to scan the right hands of 100 males and 91 girls and measure their fingerprints. The results showed that both simple and complex regression equations may be used to predict stature from handprint measurements. The shortest handprint length in males was determined to be ±4.54 cm, while in females it was ±5.38 cm.

A research was carried out by Sen et al. (2019) to determine the sex of an indigenous Eastern Indian people using the lengths of their index and ring fingers. The study included 500 people, 250 of whom were male and 250 of whom were female, and their ages ranged from 18 to 60. The findings showed that both the index and ring fingers were much longer in men than in women, with the ring finger being noticeably longer than the index finger in both genders. The results show that the length of the index and ring fingers differs between the sexes.

Researchers Ibrahim et al. (2018) sought to identify the sex of a north Saudi community by measuring their hands and comparing the lengths of their index fingers to their ring fingers. Five hundred students, ranging in age from eighteen to thirty, had their hands measured for length, width, index, and index to ring finger ratio. No statistically significant difference was found between the right and left hands, although men's hands had an average length of 1.3 cm, width of 0.96 cm, and index of 2.93 cm that was higher than women's. If the cut off point index is more than 41.23, it indicates a male hand, and if it is less than or equal to 41.23, it indicates a female hand. In relation to the ratio of index to ring finger, it was discovered that females had a larger ratio than men. A ratio of less than 0.920 indicated a female hand, while a ratio of 0.920 or above indicated a male hand.

Two hundred medical students, 100 male and 100 female, aged 18–25, from an indigenous community in the Jammu and Kashmir area of northern India, were studied by Khan et al. (2017) to determine the digit ratio (2D: 4D) as an anthropometric indicator for sexual dimorphism. Males had a lower mean 2D: 4D digit ratio (0.975) than females (0.984), indicating a statistically significant difference between the sexes. Based on the results, a ratio more than 0.975 is indicative of a female hand while a ratio less than or equal to 0.975 is indicative of a male hand.

The sexual dimorphism in digit ratios resulting from dorsal digit length was studied by Kumar et al.

(2017) in both adults and children. With the exception of the thumb, all finger lengths were measured in three separate investigations using independent samples. According to the findings, when it comes to digit ratios that contain the number 5 as one of its components, males tend to have lower values than women do (4D: 5D, 3D: 5D, and 2D: 5D ratios). It follows that the sex hormone effects may be more pronounced for the 2D: 4D ratio evaluated ventrally compared to the digit ratio including the 5th digit.

An anthropometric study was carried out by Nidiaputri and Ardiyanto (2017), which included 202 young adult females from Indonesia. The survey measured 24 hand dimensions. The sample included people from the Batak, Javanese, and Sundanese ethnic groups. Compared to Batak and Javanese people, Sundanese people tended to have narrower and thinner hands, according to the research. There was a reported substantial difference in hand dimensions between the study's findings and those of other nations, including Jordanians, Bangladeshis, Chinese from Hong Kong, Nigerians, Vietnamese, and UK residents.

## 3. Methodology

### Objective

To assess anthropometric hand dimensions and explore potential variations among selected North Indian populations, highlighting any socio-demographic and occupational influences.

### Study Design

A detailed cross-sectional analysis was conducted, focusing on a representative subset of the North Indian population. This design facilitated the exploration of anthropometric hand dimension variations across different socio-demographic groups.

### Population and Sample Size

From the broader study population outlined in below Table, a focused subset of 100 individuals was selected through stratified random sampling. This subset aimed to ensure representation across the different zones and population groups previously identified, maintaining a balance between genders and socio-demographic backgrounds.

| Zone of India | Area of Study | Population groups | Sample size (n) | | Total |
|---|---|---|---|---|---|
| | | | Males | Females | |
| North | Delhi | Gujar | 14 | 14 | 28 |
| | Uttar Pradesh | Jat | 13 | 13 | 26 |
| | | Kumbhar | 5 | 5 | 10 |
| | Uttarakhand | Kumaoni Brahmin | 5 | 5 | 10 |
| | | Kumaoni Rajput | 6 | 7 | 13 |
| | | Kumaoni Shilpkar | 6 | 7 | 13 |
| Total (North Zone) | | | 49 | 51 | 100 |

### Data Collection Procedures

- **Anthropometric Measurements**: Hand dimensions were measured using standard anthropometric tools. Measurements included hand length, breadth, palm length, and digit dimensions. The measurement procedures adhered to ISAK guidelines to ensure consistency and reliability.
- **Sample Specifics**: The focused sample of 100 participants underwent detailed measurement sessions, with each measurement recorded by trained anthropometrists to minimize error.

### Measurement Accuracy

- **Technical Error of Measurement (TEM)**, **Relative TEM (rTEM)**, and **Coefficient of Reliability (R)** were calculated for the sample of 100 to evaluate the precision and reliability of the anthropometric data collected, ensuring the methodological rigor of the study.

Statistical Analysis

- **Descriptive Analysis**: Mean, standard deviation, and range for each anthropometric variable were calculated, providing a comprehensive overview of hand dimensions within the sample.
- **ANOVA**: Employed to examine differences in anthropometric variables among different socio-demographic groups within the focused sample. F-values and p-values were reported to highlight significant disparities.
- **Post-hoc LSD Test**: Conducted to pinpoint specific group differences following ANOVA, identifying where significant variances in hand dimensions exist among the study's subgroups.

Ethical Considerations

Prior to data collection, informed consent was obtained from all participants. The study was approved by the institutional review board, adhering to ethical standards for research involving human subjects.

Limitations

This focused analysis on a sample of 100 may limit the generalizability of findings to the entire North Indian population. Additionally, the cross-sectional design precludes causation inference.

## 4. Results

**Table 4.1 Socio-Demographic Profile of Respondents**

| Zone of India | Area of Study | Population Group | Gender | Sample Size (n) | Educational Qualification Distribution (%) | Occupational Level Distribution (%) | Mean Age (Years) ± SD | Range of Age (Years) | Mean Stature (cm) ± SD | Range of Stature (cm) |
|---|---|---|---|---|---|---|---|---|---|---|
| North | Delhi | Gujar | M | 14 | Illiterate: 3.1, Primary: 1.2, Middle: 11.2, High: 13.7, Intermediate: 39.8, Grad. & Post Grad.: 31.1 | Agriculture: 6.2, Business: 34.2, Govt. Sector: 12.4, Private Sector: 3.1, Student: 26.7, House worker: 1.2, Unemployed: 13.7, Miscellaneous: 2.5 | 31.5 ± 12.4 | 18 – 60 | 170.5 ± 7.06 | 152.0 – 191.9 |
| | | | F | 14 | Illiterate: 35.0, Primary: 10.0, Middle: 12.5, High: 11.3, Intermediate: 11.9, Grad. & Post Grad.: 19.4 | House worker: 76.3, Student: 8.1, Govt. Sector: 0.6, Unemployed: 14.4, Miscellaneous: 0.6 | 36.8 ± 13.1 | 18 – 60 | 156.3 ± 5.74 | 143.5 – 172.4 |
| Uttar Pradesh | | Jat | M | 13 | Illiterate: 11.0, Primary: 1.9, Middle: 5.8, High: 10.3, Intermediate: 29.7, | Agriculture: 60.0, Business: 1.3, Govt. Sector: 8.4, Student: 25.8, Unemployed: 3.2, | 38.7 ± 14.8 | 18 – 60 | 170.75 ± 6.84 | 150.4 – 191.0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Grad. & Post Grad.: 41.3 | Miscellaneous: 0.6 | | | | |
| | | | F | 13 | Illiterate: 23.7, Primary: 3.3, Middle: 15.1, High: 15.1, Intermediate: 15.8, Grad. & Post Grad.: 27.0 | House worker: 71.1, Student: 20.4, Govt. Sector: 1.3, Unemployed: 6.6, Miscellaneous: 0.7 | 34.9 ± 13.6 | 18 – 60 | 156.04 ± 5.89 | 139.6 – 174.5 |
| | | Kumbhar | M | 4 | Illiterate: 19.1, Primary: 12.8, Middle: 6.4, High: 12.8, Intermediate: 38.3, Grad. & Post Grad.: 10.6 | Business: 10.6, Student: 29.8, Unemployed: 8.5, Miscellaneous: 48.9 | 31.5 ± 14.0 | 18 – 60 | 164.6 ± 6.66 | 146.1 – 178.8 |
| | | | F | 5 | Illiterate: 41.1, Primary: 5.4, Middle: 8.9, High: 21.4, Intermediate: 10.7, Grad. & Post Grad.: 12.5 | House worker: 55.4, Student: 28.6, Unemployed: 12.5, Miscellaneous: 1.8 | 32.3 ± 14.9 | 18 – 60 | 152.14 ± 5.98 | 139.1 – 169.5 |
| Uttarakhand | | Kumaoni Brahmin | M | 5 | Middle: 6.6, High: 31.1, Intermediate: 31.1, Grad. & Post Grad.: 27.9 | Agriculture: 27.9, Business: 11.5, Govt. Sector: 4.9, Private Sector: 13.1, Student: 41.0 | 31.5 ± 13.2 | 18 – 60 | 157.24 ± 7.77 | 140 – 171 |
| | | | F | 5 | Illiterate: 7.9, Middle: 11.1, High: 30.2, Intermediate: 33.3, Grad. & Post Grad.: 15.9 | House worker: 50.8, Student: 28.6, Govt. Sector: 1.6 | 32.0 ± 13.3 | 18 – 60 | 145.71 ± 4.09 | 138 – 156.7 |
| | | Kumaoni Rajput | M | 6 | Illiterate: 8.6, Primary: | Agriculture: 20.0, Business: | 31.2 ± 14.7 | 18 - 60 | 157.35 ± 10.01 | 139.9 – 174.5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4.3, Middle: 4.3, High: 52.9, Intermediate: 27.1 | 7.1, Govt. Sector: 8.6, Student: 51.4 | | | | |
| | | | F | 7 | Illiterate: 36.5, Primary: 4.7, Middle: 10.6, High: 31.8, Intermediate: 10.6 | House worker: 57.6, Student: 37.6, Govt. Sector: 2.4 | 33.6 ± 15.2 | 18 – 60 | 150.73 ± 6.26 | 135.9 – 168.0 |
| | | Kumaoni Shilpkar | M | 6 | Illiterate: 11.3, Primary: 5.6, Middle: 16.9, High: 21.1, Intermediate: 45.1 | Agriculture: 12.7, Business: 26.8, Govt. Sector: 5.6, Student: 33.8 | 31.9 ± 13.9 | 18 - 60 | 160.26 ± 6.49 | 150.0 – 179.0 |
| | | | F | 7 | Illiterate: 41.8, Primary: 9.0, Middle: 17.9, High: 29.9, Intermediate: 1.5, Grad. & Post Grad.: - | House worker: 71.6, Student: 23.9, Govt. Sector: 1.5, Private Sector: -, Unemployed: 1.5, Miscellaneous: - | 33.9 ± 14.1 | 18 – 60 | 151.18 ± 5.92 | 138.6 – 166.7 |

## Technical Error of the Hand Anthropometric Measurements

**Table 4.2 : Precision Estimates of Hand Anthropometric Measurements (n = 30)**

| S.No. | Hand Anthropometric Measurements | | TEM | rTEM (%) | R |
|---|---|---|---|---|---|
| 1. | Hand Length (HL) | R | 0.138 | 0.783 | 0.990 |
| | | L | 0.130 | 0.737 | 0.992 |
| 2. | Hand Breadth - I (HB-I) | R | 0.062 | 1.261 | 0.975 |
| | | L | 0.061 | 1.275 | 0.980 |
| 3. | Hand Breadth - II (HB-II) | R | 0.047 | 0.662 | 0.991 |
| | | L | 0.041 | 0.566 | 0.994 |
| 4. | Hand Breadth - III (HB-III) | R | 0.062 | 0.772 | 0.989 |
| | | L | 0.063 | 0.781 | 0.985 |
| 4. | Maximum Hand Breadth (MHB) | R | 0.077 | 0.763 | 0.987 |
| | | L | 0.067 | 0.669 | 0.991 |
| 6. | Palm Length (PL) | R | 0.086 | 0.852 | 0.988 |
| | | L | 0.083 | 0.817 | 0.990 |
| 7. | Palm Breadth (PB) | R | 0.034 | 0.419 | 0.996 |
| | | L | 0.053 | 0.662 | 0.992 |
| 8. | 1st Digit Length (D1L) | R | 0.052 | 0.826 | 0.988 |
| | | L | 0.061 | 0.967 | 0.978 |
| 9. | 2nd Digit Length (D2L) | R | 0.039 | 0.558 | 0.995 |

| | | | | | |
|---|---|---|---|---|---|
| | | L | 0.048 | 0.693 | 0.994 |
| 10. | 3rd Digit Length (D3L) | R | 0.041 | 0.535 | 0.997 |
| | | L | 0.050 | 0.652 | 0.994 |
| 11. | 4th Digit Length (D4L) | R | 0.039 | 0.546 | 0.996 |
| | | L | 0.062 | 0.868 | 0.990 |
| 12. | 5th Digit Length (D5L) | R | 0.048 | 0.843 | 0.992 |
| | | L | 0.045 | 0.762 | 0.993 |
| 13. | 1st Digit Breadth (D1B) | R | 0.022 | 1.102 | 0.971 |
| | | L | 0.018 | 0.925 | 0.982 |
| 14. | 2nd Digit Breadth (D2B) | R | 0.018 | 0.989 | 0.979 |
| | | L | 0.018 | 1.007 | 0.986 |
| 14. | 3rd Digit Breadth (D3B) | R | 0.018 | 0.975 | 0.978 |
| | | L | 0.013 | 0.709 | 0.991 |
| 16. | 4th Digit Breadth (D4B) | R | 0.018 | 1.030 | 0.980 |
| | | L | 0.013 | 0.744 | 0.991 |
| 17. | 5th Digit Breadth (D5B) | R | 0.013 | 0.809 | 0.984 |
| | | L | 0.013 | 0.815 | 0.989 |
| 18. | Wrist Breadth (WB) | R | 0.034 | 0.616 | 0.993 |
| | | L | 0.041 | 0.726 | 0.990 |

TEM – Technical error of measurements; r TEM – Relative TEM; R – Coefficient of Reliability

**Descriptive Statistics of Hand Anthropometric Measurements**

**Table 4.3: Various Hand Anthropometric Variables (in cm) among Males and Females of Gujar from Delhi**

| S.No. | Variables | | Gujar Males (n = 14) | | | | Gujar Females (n = 14) | | | | t – value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Mean | SD | Min | Max | Mean | SD | |
| 1. | HL | R | 14.7 | 21.1 | 18.71 | 0.94 | 14.1 | 20.0 | 17.26 | 0.84 | 14.49*** |
| | | L | 14.9 | 21.1 | 18.72 | 0.95 | 14.0 | 19.9 | 17.24 | 0.87 | 14.59*** |
| 2. | HB – I | R | 4.5 | 6.3 | 4.18 | 0.36 | 4.0 | 7.3 | 4.71 | 0.39 | 11.18*** |
| | | L | 4.1 | 4.9 | 4.07 | 0.35 | 3.7 | 7.3 | 4.66 | 0.40 | 9.79*** |
| 3. | HB – II | R | 4.6 | 9.0 | 7.56 | 0.55 | 4.6 | 8.9 | 6.94 | 0.51 | 10.45*** |
| | | L | 6.6 | 8.8 | 7.66 | 0.41 | 4.6 | 8.9 | 6.95 | 0.48 | 14.30*** |
| 4. | HB – III | R | 7.5 | 10.6 | 8.58 | 0.49 | 6.0 | 10.1 | 7.79 | 0.47 | 14.60*** |
| | | L | 7.1 | 10.6 | 8.55 | 0.48 | 6.4 | 10.1 | 7.78 | 0.50 | 13.99*** |
| 4. | MHB | R | 9.3 | 12.6 | 10.72 | 0.64 | 8.0 | 11.6 | 9.58 | 0.52 | 17.56*** |
| | | L | 9.4 | 12.6 | 10.65 | 0.59 | 7.6 | 11.6 | 9.48 | 0.58 | 17.88*** |
| 6. | PL | R | 8.5 | 12.5 | 10.61 | 0.69 | 8.0 | 11.4 | 9.66 | 0.56 | 13.46*** |
| | | L | 7.4 | 12.1 | 10.60 | 0.67 | 6.9 | 11.3 | 9.65 | 0.60 | 13.38*** |
| 7. | PB | R | 7.2 | 10.0 | 8.63 | 0.54 | 6.0 | 9.2 | 7.64 | 0.45 | 17.76*** |
| | | L | 7.5 | 9.7 | 8.57 | 0.5 | 6.0 | 9.7 | 7.59 | 0.50 | 17.64*** |
| 8. | D1L | R | 4.5 | 8.1 | 6.55 | 0.42 | 4.8 | 7.7 | 6.07 | 0.42 | 10.31*** |
| | | L | 4.2 | 8.1 | 6.55 | 0.46 | 4.6 | 7.7 | 6.06 | 0.44 | 9.89*** |
| 9. | D2L | R | 4.8 | 8.6 | 7.23 | 0.49 | 4.9 | 8.1 | 6.76 | 0.40 | 9.37*** |
| | | L | 4.7 | 8.6 | 7.24 | 0.49 | 4.7 | 8.1 | 6.75 | 0.40 | 10.08*** |
| 10. | D3L | R | 4.5 | 9.5 | 8.02 | 0.56 | 6.3 | 8.9 | 7.46 | 0.45 | 9.93*** |
| | | L | 6.6 | 9.5 | 8.01 | 0.52 | 4.9 | 8.5 | 7.41 | 0.52 | 10.39*** |
| 11. | D4L | R | 6.0 | 9.2 | 7.51 | 0.5 | 4.6 | 8.1 | 6.88 | 0.48 | 9.22*** |
| | | L | 6.1 | 9.2 | 7.49 | 0.51 | 4.6 | 8 | 6.86 | 0.49 | 9.47*** |
| 12. | D5L | R | 4.8 | 8.0 | 6.01 | 0.49 | 4.3 | 8.1 | 4.58 | 0.45 | 8.29*** |
| | | L | 4.8 | 8.0 | 6.00 | 0.48 | 4.3 | 8.1 | 4.59 | 0.47 | 7.69*** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13. | D1B | R | 1.7 | 3.0 | 2.09 | 0.16 | 1.5 | 2.4 | 1.94 | 0.13 | 9.60*** |
| | | L | 1.7 | 3.0 | 2.08 | 0.15 | 1.5 | 2.4 | 1.89 | 0.14 | 11.65*** |
| 14. | D2B | R | 1.6 | 2.2 | 1.92 | 0.12 | 1.5 | 2.1 | 1.77 | 0.12 | 11.32*** |
| | | L | 1.7 | 2.2 | 1.90 | 0.12 | 1.5 | 2.1 | 1.75 | 0.12 | 11.37*** |
| 14. | D3B | R | 1.7 | 2.3 | 1.96 | 0.12 | 1.5 | 2.2 | 1.78 | 0.12 | 13.56*** |
| | | L | 1.4 | 2.3 | 1.93 | 0.13 | 1.4 | 2.2 | 1.75 | 0.12 | 13.34*** |
| 16. | D4B | R | 1.5 | 2.4 | 1.85 | 0.12 | 1.5 | 2.1 | 1.68 | 0.11 | 13.03*** |
| | | L | 1.5 | 2.2 | 1.84 | 0.12 | 1.3 | 2.1 | 1.66 | 0.12 | 12.96*** |
| 17. | D5B | R | 1.3 | 2.0 | 1.66 | 0.12 | 1.3 | 1.8 | 1.52 | 0.12 | 10.29*** |
| | | L | 1.3 | 2.0 | 1.64 | 0.11 | 1.3 | 1.8 | 1.51 | 0.12 | 10.05*** |
| 18. | WB | R | 4.1 | 6.7 | 4.79 | 0.34 | 4.6 | 6.1 | 4.24 | 0.29 | 14.62*** |
| | | L | 4.1 | 6.8 | 4.79 | 0.36 | 4.6 | 6.1 | 4.25 | 0.28 | 14.77*** |

Min – Minimum; Max – Maximum; SD – Standard deviation; R – Right; L – Left; ***. P<0.001;

**Table 4.4: Various Hand Anthropometric Variables (in cm) among Males and Females of Jat from Uttar Pradesh**

| S.No. | Variables | | Jat Males (n = 13) | | | | Jat Females (n = 13) | | | | t – value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Mean | SD | Min | Max | Mean | SD | |
| 1. | HL | R | 16.7 | 20.9 | 18.93 | 0.93 | 15 | 19.4 | 17.33 | 0.89 | 14.40*** |
| | | L | 16.7 | 20.9 | 18.94 | 0.93 | 15 | 19.4 | 17.33 | 0.89 | 14.39*** |
| 2. | HB – I | R | 4.3 | 6.2 | 4.21 | 0.31 | 3.9 | 7.8 | 4.69 | 0.46 | 11.68*** |
| | | L | 4.3 | 6.2 | 4.21 | 0.31 | 3.9 | 7.8 | 4.68 | 0.46 | 11.70*** |
| 3. | HB – II | R | 4.2 | 8.7 | 7.62 | 0.5 | 4.4 | 8.2 | 6.96 | 0.43 | 12.30*** |
| | | L | 4.2 | 8.7 | 7.62 | 0.5 | 4.3 | 8.3 | 6.96 | 0.44 | 12.21*** |
| 4. | HB – III | R | 6.1 | 10.4 | 8.53 | 0.52 | 4.7 | 9.2 | 7.79 | 0.45 | 13.42*** |
| | | L | 6.1 | 10.4 | 8.53 | 0.52 | 4.7 | 9.2 | 7.78 | 0.46 | 13.43*** |
| 4. | MHB | R | 8.5 | 11.9 | 10.56 | 0.57 | 7.2 | 11.1 | 9.51 | 0.56 | 16.32*** |
| | | L | 8.5 | 11.9 | 10.57 | 0.57 | 7.2 | 10.9 | 9.49 | 0.56 | 16.58*** |
| 6. | PL | R | 7.6 | 11.9 | 10.72 | 0.67 | 7.3 | 11.2 | 9.75 | 0.63 | 13.03*** |
| | | L | 7.6 | 11.9 | 10.72 | 0.67 | 7.3 | 11.2 | 9.75 | 0.63 | 13.04*** |
| 7. | PB | R | 6.5 | 9.6 | 8.40 | 0.51 | 4.5 | 8.5 | 7.52 | 0.48 | 14.47*** |
| | | L | 6.5 | 9.6 | 8.40 | 0.51 | 4.5 | 8.5 | 7.51 | 0.49 | 14.59*** |
| 8. | D1L | R | 4.4 | 7.9 | 6.58 | 0.44 | 4.8 | 7.0 | 4.97 | 0.45 | 12.14*** |
| | | L | 4.4 | 7.9 | 6.58 | 0.44 | 4.8 | 7.0 | 4.96 | 0.45 | 12.18*** |
| 9. | D2L | R | 6.0 | 8.3 | 7.37 | 0.44 | 4.3 | 8.4 | 6.77 | 0.46 | 11.61*** |
| | | L | 6.0 | 8.3 | 7.37 | 0.44 | 4.3 | 8.4 | 6.76 | 0.46 | 11.62*** |
| 10. | D3L | R | 4.2 | 9.0 | 8.03 | 0.56 | 6.1 | 8.8 | 7.46 | 0.47 | 9.78*** |
| | | L | 4.2 | 9.0 | 8.03 | 0.56 | 6.1 | 8.8 | 7.45 | 0.47 | 9.84*** |
| 11. | D4L | R | 6.4 | 8.7 | 7.64 | 0.46 | 4.4 | 8.2 | 6.90 | 0.49 | 11.73*** |
| | | L | 6.4 | 8.7 | 7.69 | 0.46 | 4.4 | 8.2 | 6.89 | 0.50 | 11.72*** |
| 12. | D5L | R | 4.1 | 8.5 | 6.17 | 0.45 | 4.2 | 8.0 | 4.61 | 0.60 | 9.25*** |
| | | L | 4.1 | 8.5 | 6.18 | 0.47 | 4.2 | 8.0 | 4.61 | 0.60 | 9.22*** |
| 13. | D1B | R | 1.9 | 2.8 | 2.16 | 0.13 | 1.5 | 2.5 | 1.96 | 0.14 | 12.84*** |
| | | L | 1.9 | 2.8 | 2.16 | 0.13 | 1.5 | 2.5 | 1.95 | 0.15 | 12.87*** |
| 14. | D2B | R | 1.7 | 2.2 | 1.92 | 0.11 | 1.5 | 2.0 | 1.75 | 0.13 | 13.31*** |
| | | L | 1.7 | 2.2 | 1.92 | 0.11 | 1.5 | 2.0 | 1.74 | 0.13 | 13.32*** |
| 14. | D3B | R | 1.7 | 2.3 | 1.98 | 0.11 | 1.4 | 2.1 | 1.78 | 0.12 | 14.36*** |
| | | L | 1.7 | 2.3 | 1.98 | 0.11 | 1.4 | 2.1 | 1.78 | 0.12 | 14.36*** |
| 16. | D4B | R | 1.6 | 2.1 | 1.87 | 0.11 | 1.3 | 1.9 | 1.68 | 0.10 | 16.70*** |
| | | L | 1.6 | 2.1 | 1.87 | 0.11 | 1.3 | 1.9 | 1.68 | 0.10 | 16.70*** |
| 17. | D5B | R | 1.4 | 2.0 | 1.69 | 0.12 | 1.2 | 1.9 | 1.51 | 0.12 | 12.79*** |
| | | L | 1.4 | 2.0 | 1.69 | 0.12 | 1.2 | 1.9 | 1.51 | 0.12 | 12.76*** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18. | WB | R | 4.9 | 6.4 | 4.65 | 0.32 | 4.3 | 6.0 | 4.10 | 0.31 | 14.28*** |
| | | L | 4.9 | 6.4 | 4.65 | 0.32 | 4.3 | 6.0 | 4.09 | 0.31 | 14.31*** |

Min – Minimum; Max – Maximum; SD – Standard deviation; R – Right; L – Left; ***. P<0.001;

**Table 4.5: Various Hand Anthropometric Variables (in cm) among Males and Females of Kumbhar from Uttar Pradesh**

| S.No. | Variables | | Kumbhar Males (n = 5) | | | | Kumbhar Females (n =5) | | | | t – value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Mean | SD | Min | Max | Mean | SD | |
| 1. | HL | R | 16.9 | 20.3 | 18.34 | 0.74 | 14.6 | 19.1 | 16.66 | 0.88 | 10.36*** |
| | | L | 16.8 | 20.1 | 18.34 | 0.73 | 14.5 | 19.1 | 16.65 | 0.88 | 10.39*** |
| 2. | HB – I | R | 4.4 | 6.0 | 4.10 | 0.34 | 3.8 | 4.2 | 4.53 | 0.30 | 9.12*** |
| | | L | 4.5 | 4.9 | 4.09 | 0.33 | 3.8 | 4.2 | 4.52 | 0.31 | 9.13*** |
| 3. | HB – II | R | 6.8 | 8.7 | 7.52 | 0.43 | 4.6 | 7.8 | 6.81 | 0.45 | 8.09*** |
| | | L | 6.5 | 8.6 | 7.52 | 0.44 | 4.6 | 7.8 | 6.8 | 0.46 | 8.15*** |
| 4. | HB – III | R | 7.7 | 10.4 | 8.43 | 0.47 | 6.6 | 9.2 | 7.61 | 0.49 | 8.69*** |
| | | L | 7.6 | 10.4 | 8.42 | 0.47 | 6.6 | 9.2 | 7.61 | 0.49 | 8.58*** |
| 4. | MHB | R | 9.0 | 12 | 10.33 | 0.57 | 7.7 | 10.7 | 9.23 | 0.6 | 9.50*** |
| | | L | 9.1 | 12.2 | 10.29 | 0.61 | 7.8 | 10.5 | 9.22 | 0.59 | 9.04*** |
| 6. | PL | R | 7.8 | 11.5 | 10.28 | 0.63 | 7.1 | 10.7 | 9.15 | 0.65 | 8.86*** |
| | | L | 7.9 | 11.5 | 10.27 | 0.61 | 7.3 | 10.4 | 9.14 | 0.63 | 9.12*** |
| 7. | PB | R | 6.8 | 9.6 | 8.21 | 0.49 | 4.7 | 8.9 | 7.34 | 0.54 | 8.49*** |
| | | L | 6.9 | 9.8 | 8.18 | 0.52 | 4.9 | 8.7 | 7.33 | 0.52 | 8.21*** |
| 8. | D1L | R | 4.5 | 7.3 | 6.42 | 0.41 | 4.5 | 7.8 | 4.72 | 0.53 | 7.37*** |
| | | L | 4.4 | 7.3 | 6.42 | 0.43 | 4.5 | 7.7 | 4.72 | 0.52 | 7.35*** |
| 9. | D2L | R | 6.0 | 8.0 | 7.04 | 0.46 | 4.2 | 7.7 | 6.54 | 0.45 | 4.53*** |
| | | L | 6.1 | 8.0 | 7.04 | 0.45 | 4.4 | 7.6 | 6.54 | 0.44 | 4.65*** |
| 10. | D3L | R | 6.6 | 8.7 | 7.82 | 0.47 | 6 | 8.6 | 7.23 | 0.54 | 4.87*** |
| | | L | 6.8 | 8.9 | 7.83 | 0.47 | 6 | 8.6 | 7.22 | 0.55 | 6.06*** |
| 11. | D4L | R | 6.5 | 8.8 | 7.39 | 0.46 | 4.7 | 7.8 | 6.74 | 0.48 | 6.65*** |
| | | L | 6.4 | 8.6 | 7.38 | 0.45 | 4.6 | 7.7 | 6.71 | 0.49 | 6.84*** |
| 12. | D5L | R | 4.0 | 8.6 | 4.89 | 0.60 | 4.7 | 6.1 | 4.36 | 0.36 | 4.48*** |
| | | L | 4.1 | 7.0 | 4.88 | 0.46 | 4.6 | 6 | 4.36 | 0.35 | 6.51*** |
| 13. | D1B | R | 1.8 | 2.4 | 2.12 | 0.15 | 1.7 | 2.2 | 1.89 | 0.13 | 8.57*** |
| | | L | 1.7 | 2.4 | 2.11 | 0.16 | 1.7 | 2.2 | 1.88 | 0.13 | 7.95*** |
| 14. | D2B | R | 1.7 | 2.2 | 1.86 | 0.11 | 1.5 | 2.0 | 1.69 | 0.10 | 8.43*** |
| | | L | 1.7 | 2.2 | 1.85 | 0.11 | 1.5 | 2.0 | 1.68 | 0.10 | 8.12*** |
| 14. | D3B | R | 1.8 | 2.2 | 1.92 | 0.10 | 1.5 | 1.9 | 1.74 | 0.11 | 9.04*** |
| | | L | 1.7 | 2.2 | 1.92 | 0.11 | 1.5 | 1.9 | 1.73 | 0.11 | 8.84*** |
| 16. | D4B | R | 1.7 | 2.1 | 1.82 | 0.11 | 1.4 | 1.9 | 1.64 | 0.12 | 8.20*** |
| | | L | 1.7 | 2.1 | 1.81 | 0.11 | 1.4 | 1.9 | 1.64 | 0.12 | 7.85*** |
| 17. | D5B | R | 1.4 | 2.0 | 1.62 | 0.11 | 1.2 | 1.7 | 1.46 | 0.11 | 7.24*** |
| | | L | 1.4 | 2.0 | 1.62 | 0.12 | 1.2 | 1.7 | 1.46 | 0.11 | 6.81*** |
| 18. | WB | R | 4.8 | 6.4 | 4.45 | 0.33 | 4.4 | 4.9 | 4.89 | 0.28 | 9.32*** |
| | | L | 4.9 | 6.3 | 4.43 | 0.33 | 4.5 | 4.8 | 4.90 | 0.27 | 9.06*** |

Min – Minimum; Max – Maximum; SD – Standard deviation; R – Right; L – Left; ***. P<0.001
;

**Table 4.6: Various Hand Anthropometric Variables (in cm) among Males and Females of Kumaoni Brahmin from Uttarakhand**

| S.No. | Variables | | K. Brahmin Males (n = 5) | | | | K. Brahmin Females (n = 5) | | | | t – value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Mean | SD | Min | Max | Mean | SD | |
| 1. | HL | R | 14.5 | 20.5 | 17.68 | 1.23 | 14.9 | 17.7 | 16.37 | 0.73 | 7.27*** |
| | | L | 14.4 | 20.5 | 17.75 | 1.21 | 14.9 | 17.7 | 16.39 | 0.75 | 7.54*** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2. | HB – I | R | 4.3 | 4.9 | 4.14 | 0.49 | 4.0 | 4.8 | 4.78 | 0.34 | 4.68*** |
| | | L | 4.4 | 4.8 | 4.13 | 0.46 | 4.0 | 4.7 | 4.79 | 0.34 | 4.70*** |
| 3. | HB – II | R | 4.7 | 8.4 | 7.39 | 0.61 | 4.9 | 8.5 | 7.04 | 0.53 | 3.33*** |
| | | L | 4.7 | 8.4 | 7.34 | 0.61 | 4.9 | 8.0 | 6.94 | 0.49 | 4.07*** |
| 4. | HB – III | R | 6.4 | 9.4 | 8.11 | 0.62 | 7.0 | 9.2 | 7.73 | 0.44 | 3.98*** |
| | | L | 6.7 | 9.4 | 8.10 | 0.60 | 6.9 | 9.6 | 7.61 | 0.44 | 4.17*** |
| 4. | MHB | R | 7.1 | 11.5 | 10.07 | 0.82 | 7.7 | 11.2 | 9.47 | 0.58 | 4.69*** |
| | | L | 8.6 | 11.6 | 10.10 | 0.72 | 8.5 | 11.3 | 9.40 | 0.53 | 6.17*** |
| 6. | PL | R | 8.1 | 10.8 | 9.71 | 0.62 | 7.6 | 10.1 | 9.01 | 0.49 | 6.97*** |
| | | L | 8.1 | 10.9 | 9.71 | 0.66 | 6.6 | 10.1 | 8.89 | 0.64 | 7.00*** |
| 7. | PB | R | 4.0 | 9.2 | 8.01 | 0.70 | 4.8 | 9.1 | 7.53 | 0.50 | 4.35*** |
| | | L | 6.9 | 9.3 | 8.05 | 0.58 | 6.8 | 9.2 | 7.49 | 0.45 | 6.05*** |
| 8. | D1L | R | 4.8 | 7.3 | 4.77 | 0.59 | 4.8 | 6.4 | 4.50 | 0.37 | 3.02** |
| | | L | 4.9 | 7.3 | 4.77 | 0.57 | 4.8 | 6.4 | 4.49 | 0.37 | 3.23** |
| 9. | D2L | R | 4.4 | 8.0 | 6.71 | 0.57 | 4.7 | 9.7 | 6.43 | 0.51 | 2.93** |
| | | L | 4.4 | 8.0 | 6.72 | 0.56 | 4.7 | 7.2 | 6.37 | 0.27 | 4.37*** |
| 10. | D3L | R | 6.0 | 8.7 | 7.30 | 0.64 | 6.2 | 7.9 | 6.98 | 0.35 | 3.54*** |
| | | L | 6.0 | 8.7 | 7.28 | 0.62 | 6.2 | 8.0 | 6.98 | 0.35 | 3.35*** |
| 11. | D4L | R | 4.5 | 8.2 | 6.91 | 0.59 | 4.8 | 7.5 | 6.49 | 0.31 | 3.07** |
| | | L | 4.5 | 8.2 | 6.90 | 0.57 | 4.8 | 7.6 | 6.42 | 0.31 | 3.14** |
| 12. | D5L | R | 4.3 | 6.9 | 4.51 | 0.52 | 4.6 | 6.3 | 4.32 | 0.33 | 2.51** |
| | | L | 4.2 | 6.9 | 4.51 | 0.54 | 4.3 | 6.3 | 4.29 | 0.33 | 2.70** |
| 13. | D1B | R | 1.7 | 2.3 | 2.06 | 0.17 | 1.7 | 2.2 | 1.94 | 0.12 | 4.52*** |
| | | L | 1.7 | 2.3 | 2.04 | 0.18 | 1.7 | 2.2 | 1.91 | 0.13 | 4.94*** |
| 14. | D2B | R | 1.3 | 1.9 | 1.64 | 0.13 | 1.3 | 1.9 | 1.54 | 0.12 | 4.26*** |
| | | L | 1.3 | 1.9 | 1.63 | 0.13 | 1.3 | 1.9 | 1.52 | 0.11 | 4.18*** |
| 14. | D3B | R | 1.3 | 1.9 | 1.64 | 0.15 | 1.4 | 1.7 | 1.54 | 0.08 | 4.06*** |
| | | L | 1.3 | 1.9 | 1.62 | 0.14 | 1.4 | 1.7 | 1.51 | 0.09 | 4.18*** |
| 16. | D4B | R | 1.2 | 1.8 | 1.55 | 0.14 | 1.2 | 1.8 | 1.46 | 0.10 | 4.17*** |
| | | L | 1.2 | 1.8 | 1.54 | 0.13 | 1.2 | 1.8 | 1.44 | 0.11 | 4.77*** |
| 17. | D5B | R | 1.2 | 1.7 | 1.47 | 0.12 | 1.2 | 1.7 | 1.40 | 0.09 | 3.62*** |
| | | L | 1.2 | 1.7 | 1.45 | 0.12 | 1.1 | 1.7 | 1.37 | 0.09 | 4.19*** |
| 18. | WB | R | 4.5 | 6.0 | 4.35 | 0.42 | 4.4 | 6.0 | 4.08 | 0.30 | 4.11*** |
| | | L | 4.5 | 6.0 | 4.35 | 0.41 | 4.4 | 4.9 | 4.08 | 0.30 | 4.11*** |

Min – Minimum; Max – Maximum; SD – Standard deviation; R – Right; L – Left; ***. P<0.001; **. P<0.01;

**Table 4.7: Various Hand Anthropometric Variables (in cm) among Males and Females of Kumaoni Rajput from Uttarakhand**

| S.No. | Variables | | K. Rajput Males (n = 6) | | | | K. Rajput Females (n = 7) | | | | t – value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Mean | SD | Min | Max | Mean | SD | |
| 1. | HL | R | 14.2 | 20.1 | 17.79 | 1.25 | 14.9 | 19.3 | 16.73 | 1.02 | 4.86*** |
| | | L | 14.2 | 20.0 | 17.80 | 1.24 | 14.9 | 19.1 | 16.74 | 1.02 | 4.84*** |
| 2. | HB – I | R | 4.3 | 4.8 | 4.12 | 0.42 | 4.0 | 4.8 | 4.85 | 0.36 | 4.28*** |
| | | L | 4.3 | 6.1 | 4.12 | 0.43 | 4.0 | 4.8 | 4.85 | 0.35 | 4.36*** |
| 3. | HB – II | R | 4.7 | 8.4 | 7.42 | 0.51 | 4.9 | 8.5 | 7.09 | 0.51 | 3.99*** |
| | | L | 4.7 | 8.3 | 7.39 | 0.50 | 4.9 | 8.1 | 7.00 | 0.49 | 4.82*** |
| 4. | HB – III | R | 4.9 | 9.2 | 8.14 | 0.60 | 7.0 | 9.2 | 7.79 | 0.43 | 4.28*** |
| | | L | 4.9 | 9.1 | 8.12 | 0.57 | 6.9 | 9.6 | 7.68 | 0.44 | 4.31*** |
| 4. | MHB | R | 7.7 | 11.2 | 10.08 | 0.69 | 7.7 | 11.2 | 9.57 | 0.61 | 4.91*** |
| | | L | 7.7 | 11.2 | 10.08 | 0.70 | 8.5 | 11.2 | 9.50 | 0.58 | 4.61*** |
| 6. | PL | R | 7.6 | 11.1 | 9.74 | 0.65 | 7.6 | 10.5 | 9.15 | 0.56 | 6.13*** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | 7.6 | 11.1 | 9.75 | 0.66 | 6.6 | 10.5 | 9.06 | 0.69 | 6.32*** |
| 7. | PB | R | 4.8 | 9.0 | 8.02 | 0.63 | 4.8 | 9.1 | 7.61 | 0.53 | 4.43*** |
| | | L | 4.8 | 9.1 | 8.02 | 0.63 | 6.8 | 9.1 | 7.57 | 0.50 | 4.92*** |
| 8. | D1L | R | 4.7 | 7.0 | 4.86 | 0.53 | 4.8 | 6.5 | 4.51 | 0.41 | 4.62*** |
| | | L | 4.7 | 7.0 | 4.86 | 0.53 | 4.8 | 6.5 | 4.50 | 0.43 | 4.66*** |
| 9. | D2L | R | 4.7 | 7.6 | 6.80 | 0.52 | 4.6 | 9.7 | 6.44 | 0.52 | 4.20*** |
| | | L | 4.7 | 7.7 | 6.79 | 0.51 | 4.7 | 7.5 | 6.42 | 0.37 | 4.44*** |
| 10. | D3L | R | 6.1 | 8.6 | 7.46 | 0.58 | 6.2 | 8.2 | 7.04 | 0.40 | 4.32*** |
| | | L | 6.1 | 8.5 | 7.46 | 0.58 | 6.2 | 8.0 | 7.03 | 0.38 | 4.58*** |
| 11. | D4L | R | 4.9 | 7.9 | 6.99 | 0.53 | 4.5 | 7.6 | 6.50 | 0.40 | 4.92*** |
| | | L | 4.9 | 7.8 | 6.97 | 0.54 | 4.5 | 7.6 | 6.44 | 0.39 | 4.01*** |
| 12. | D5L | R | 4.6 | 6.7 | 4.68 | 0.50 | 4.6 | 6.3 | 4.36 | 0.36 | 4.57*** |
| | | L | 4.7 | 6.9 | 4.69 | 0.51 | 4.3 | 6.6 | 4.32 | 0.36 | 4.23*** |
| 13. | D1B | R | 1.7 | 2.3 | 2.06 | 0.14 | 1.7 | 2.2 | 1.96 | 0.13 | 4.67*** |
| | | L | 1.7 | 2.5 | 2.06 | 0.15 | 1.7 | 2.2 | 1.93 | 0.13 | 4.80*** |
| 14. | D2B | R | 1.4 | 2.0 | 1.64 | 0.13 | 1.3 | 1.9 | 1.56 | 0.12 | 3.85*** |
| | | L | 1.4 | 2.0 | 1.64 | 0.13 | 1.3 | 1.9 | 1.54 | 0.12 | 4.00*** |
| 14. | D3B | R | 1.4 | 1.9 | 1.65 | 0.13 | 1.4 | 1.9 | 1.56 | 0.10 | 4.90*** |
| | | L | 1.4 | 1.9 | 1.65 | 0.13 | 1.4 | 1.9 | 1.54 | 0.10 | 4.94*** |
| 16. | D4B | R | 1.3 | 1.8 | 1.54 | 0.12 | 1.2 | 1.8 | 1.48 | 0.10 | 3.41*** |
| | | L | 1.3 | 1.8 | 1.54 | 0.12 | 1.2 | 1.8 | 1.46 | 0.11 | 4.31*** |
| 17. | D5B | R | 1.2 | 1.7 | 1.46 | 0.11 | 1.2 | 1.7 | 1.41 | 0.09 | 3.26*** |
| | | L | 1.2 | 1.7 | 1.47 | 0.11 | 1.1 | 1.7 | 1.39 | 0.10 | 4.93*** |
| 18. | WB | R | 4.5 | 6.0 | 4.36 | 0.39 | 4.4 | 6.0 | 4.12 | 0.32 | 4.06*** |
| | | L | 4.5 | 6.0 | 4.35 | 0.39 | 4.4 | 4.9 | 4.12 | 0.32 | 4.02*** |

Min – Minimum; Max – Maximum; SD – Standard deviation; R – Right; L – Left; ***. P<0.001;

**Table 4.8: Various Hand Anthropometric Variables (in cm) among Males and Females of Kumaoni Shilpkar from Uttarakhand**

| S.No. | Variables | | K. Shilpkar Males (n = 6) | | | | K. Shilpkar Females (n = 7) | | | | t – value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Mean | SD | Min | Max | Mean | SD | |
| 1. | HL | R | 14.3 | 20.3 | 17.45 | 1.20 | 14.5 | 18.7 | 16.61 | 0.95 | 4.49*** |
| | | L | 14.1 | 20.2 | 17.57 | 1.19 | 14.5 | 18.7 | 16.72 | 0.97 | 4.56*** |
| 2. | HB – I | R | 4.2 | 4.9 | 4.00 | 0.40 | 3.7 | 4.8 | 4.65 | 0.36 | 4.41*** |
| | | L | 4.2 | 4.8 | 4.93 | 0.38 | 3.6 | 4.8 | 4.59 | 0.42 | 4.98*** |
| 3. | HB – II | R | 6.1 | 8.5 | 7.21 | 0.52 | 4.7 | 7.9 | 6.80 | 0.49 | 4.80*** |
| | | L | 6.3 | 8.5 | 7.20 | 0.49 | 4.5 | 7.9 | 6.80 | 0.51 | 4.66*** |
| 4. | HB – III | R | 6.3 | 9.2 | 7.98 | 0.50 | 6.3 | 8.4 | 7.56 | 0.43 | 4.26*** |
| | | L | 6.3 | 9.1 | 7.97 | 0.51 | 6.3 | 8.4 | 7.52 | 0.45 | 4.51*** |
| 4. | MHB | R | 8.8 | 11.5 | 10.04 | 0.61 | 8.0 | 10.7 | 9.45 | 0.58 | 4.78*** |
| | | L | 8.8 | 11.5 | 10.01 | 0.65 | 8.0 | 10.7 | 9.37 | 0.64 | 4.80*** |
| 6. | PL | R | 8.3 | 11.3 | 9.71 | 0.64 | 7.7 | 10.5 | 9.24 | 0.61 | 4.39*** |
| | | L | 8.3 | 11.2 | 9.74 | 0.64 | 4.2 | 10.3 | 9.15 | 0.86 | 4.62*** |
| 7. | PB | R | 6.8 | 9.2 | 8.02 | 0.52 | 6.3 | 8.6 | 7.55 | 0.50 | 4.35*** |
| | | L | 6.9 | 9.2 | 8.00 | 0.55 | 6.1 | 8.6 | 7.49 | 0.55 | 4.46*** |
| 8. | D1L | R | 4.0 | 7.3 | 4.93 | 0.55 | 4.9 | 6.5 | 4.56 | 0.37 | 4.65*** |
| | | L | 4.9 | 8.0 | 4.96 | 0.58 | 4.7 | 6.6 | 4.61 | 0.43 | 4.00*** |
| 9. | D2L | R | 4.9 | 8.0 | 6.77 | 0.48 | 4.3 | 7.8 | 6.52 | 0.46 | 3.72*** |
| | | L | 4.9 | 8.1 | 6.78 | 0.52 | 4.2 | 7.8 | 6.52 | 0.47 | 3.73*** |
| 10. | D3L | R | 6.2 | 8.7 | 7.49 | 0.56 | 6.0 | 8.1 | 7.11 | 0.49 | 4.25*** |
| | | L | 6.1 | 8.9 | 7.48 | 0.58 | 4.9 | 8.1 | 7.10 | 0.47 | 4.15*** |
| 11. | D4L | R | 4.7 | 8.2 | 6.91 | 0.53 | 4.8 | 7.3 | 6.58 | 0.36 | 3.37*** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | L | 4.7 | 8.2 | 6.96 | 0.55 | 4.0 | 7.5 | 6.60 | 0.43 | 3.32*** |
| 12. | D5L | R | 4.8 | 7.0 | 4.71 | 0.56 | 4.6 | 6.6 | 4.46 | 0.51 | 2.78** |
| | | L | 4.8 | 6.9 | 4.71 | 0.56 | 4.5 | 6.6 | 4.45 | 0.48 | 2.90*** |
| 13. | D1B | R | 1.7 | 2.4 | 2.02 | 0.14 | 1.5 | 2.1 | 1.90 | 0.14 | 4.96*** |
| | | L | 1.7 | 2.4 | 2.01 | 0.16 | 1.5 | 2.2 | 1.88 | 0.14 | 4.87** |
| 14. | D2B | R | 1.4 | 2.2 | 1.64 | 0.15 | 1.2 | 1.9 | 1.57 | 0.17 | 2.54** |
| | | L | 1.4 | 2.0 | 1.63 | 0.14 | 1.2 | 1.9 | 1.55 | 0.17 | 2.98** |
| 14. | D3B | R | 1.4 | 2.2 | 1.64 | 0.15 | 1.3 | 1.9 | 1.56 | 0.16 | 2.67** |
| | | L | 1.5 | 2.1 | 1.63 | 0.13 | 1.2 | 1.9 | 1.55 | 0.16 | 2.94** |
| 16. | D4B | R | 1.4 | 1.9 | 1.56 | 0.14 | 1.2 | 1.9 | 1.51 | 0.15 | 2.14* |
| | | L | 1.4 | 2.1 | 1.56 | 0.14 | 1.1 | 1.8 | 1.48 | 0.15 | 3.21** |
| 17. | D5B | R | 1.3 | 1.7 | 1.44 | 0.11 | 1.1 | 1.6 | 1.39 | 0.13 | 2.59** |
| | | L | 1.3 | 1.9 | 1.44 | 0.13 | 1.1 | 1.7 | 1.36 | 0.15 | 3.11** |
| 18. | WB | R | 4.6 | 6.3 | 4.24 | 0.39 | 4.0 | 4.9 | 4.03 | 0.39 | 3.14** |
| | | L | 4.7 | 6.3 | 4.24 | 0.38 | 4.0 | 4.9 | 4.04 | 0.40 | 3.09** |

Min – Minimum; Max – Maximum; SD – Standard deviation; R – Right hand; L – Left hand; ***. P<0.001; **. P<0.01; *. P<0.05;

**Hand Anthropometric Indices and Hand Classification**

The derived hand anthropometric indices including length – breadth and hand – breadth indices have been calculated for each of the nine population groups and based on the indices, hand phenotype has been classified which will help to investigate ethnic and regional variations.

**Table 4.9: Hand Anthropometric Indices of Gujar from Delhi**

| S.No. | Hand Indices | | Gujar Males (n = 14) | | Gujar Females (n =14) | | Hand Classification | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean | SD | Males | Females |
| 1. | LBI – I | R | 28.699* | 1.838 | 27.343* | 2.295 | ma | ma |
| | | L | 28.135* | 1.763 | 27.061* | 2.341 | ma | ma |
| 2. | LBI – II | R | 40.436* | 2.795 | 38.264* | 3.088 | mm | mm |
| | | L | 40.947* | 1.996 | 39.343* | 2.898 | mm | mm |
| 3. | LBI – III | R | 44.900* | 2.153 | 44.190* | 2.698 | mch | mch |
| | | L | 44.706* | 2.128 | 44.197* | 2.760 | mch | mch |
| 4. | HBI – A | R | 89.127* | 4.056 | 88.131* | 4.066 | wc | wc |
| | | L | 89.622* | 2.876 | 87.334* | 4.095 | wc | wc |
| 4. | HBI – B | R | 68.684* | 4.932 | 67.017* | 4.390 | pekl | pekl |
| | | L | 68.282* | 3.087 | 66.156* | 4.489 | pekl | pekl |
| 6. | HBI – C | R | 60.375* | 3.446 | 59.514* | 3.574 | mst | mst |
| | | L | 60.393* | 3.189 | 59.899* | 3.940 | mst | mst |

SD – Standard deviation; R – Right hand; L – Left hand; * statistically significant if P<0.05; ma – mesaktin; mm – medioman; mch – mesocheir; wc – weakly convergent; pekl – pemptoklin; mst – mediostrikt; for abbreviations of hand indices see table- 2.3.

**Table 4.10: Hand Anthropometric Indices of Jat from Uttar Pradesh**

| S.No | Hand Indices | | Jat Males (n = 13) | | Jat Females (n = 13) | | Hand Classification | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean | SD | Males | Females |
| 1. | LBI – I | R | 29.546* | 1.945 | 27.077* | 2.718 | ma | ma |
| | | L | 28.545* | 1.946 | 27.066* | 2.725 | ma | ma |
| 2. | LBI – II | R | 40.285* | 2.889 | 39.233* | 2.870 | mm | mm |
| | | L | 40.284* | 2.889 | 38.236* | 2.888 | mm | mm |
| 3. | LBI – III | R | 44.132* | 2.882 | 44.001* | 2.896 | mch | mch |
| | | L | 44.130* | 2.882 | 44.982* | 2.914 | mch | mch |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4. | HBI – A | R | 89.477* | 6.912 | 87.491* | 4.679 | wc | wc |
| | | L | 89.477* | 6.912 | 87.536* | 4.704 | wc | wc |
| 4. | HBI – B | R | 68.571* | 4.173 | 67.329* | 4.936 | pekl | pekl |
| | | L | 68.571* | 4.173 | 67.298* | 4.956 | pekl | pekl |
| 6. | HBI – C | R | 61.164* | 4.403 | 60.207* | 4.925 | mst | mst |
| | | L | 61.147* | 4.403 | 60.117* | 4.923 | mst | mst |

SD – Standard deviation; * statistically significant if P<0.05; ma – mesaktin; mm – medioman; mch – mesocheir; wc – weakly convergent; pekl – pemptoklin; mst – mediostrikt;

**Table 4.11: Hand Anthropometric Indices of Kumbhar from Uttar Pradesh**

| S.No. | Hand Indices | | Kumbhar Males (n = 5) | | Kumbhar Females (n =5) | | Hand Classification | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean | SD | Males | Females |
| 1. | LBI – I | R | 29.846* | 1.682 | 27.200* | 1.855 | ma | ma |
| | | L | 29.793* | 1.681 | 27.154* | 1.854 | ma | ma |
| 2. | LBI – II | R | 41.019* | 2.028 | 40.921* | 2.812 | bm | mm |
| | | L | 41.044* | 2.010 | 40.912* | 2.806 | bm | mm |
| 3. | LBI – III | R | 46.003* | 2.303 | 44.702* | 2.731 | mch | mch |
| | | L | 46.961* | 2.316 | 44.729* | 2.728 | mch | mch |
| 4. | HBI – A | R | 89.230* | 3.473 | 87.617* | 4.057 | wc | wc |
| | | L | 89.363* | 3.325 | 88.547* | 4.060 | wc | wc |
| 4. | HBI – B | R | 67.901* | 2.738 | 66.549* | 3.196 | pekl | pekl |
| | | L | 67.726* | 2.655 | 66.450* | 3.216 | pekl | pekl |
| 6. | HBI – C | R | 60.585* | 3.337 | 59.595* | 3.683 | mst | mst |
| | | L | 60.523* | 3.288 | 59.460* | 3.709 | mst | mst |

SD – Standard deviation; * statistically significant if P<0.05; ma – mesaktin; bm – breviman; mm – medioman; mch – mesocheir; wc – weakly convergent; pekl – pemptoklin; mst – mediostrikt;

**Table 4.12: Hand Anthropometric Indices of Kumaoni Brahmin from Uttarakhand**

| S.No. | Hand Indices | | K. Brahmin Males (n = 5) | | K. Brahmin Females (n =5) | | Hand Classification | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean | SD | Males | Females |
| 1. | LBI – I | R | 29.125* | 2.738 | 27.282* | 2.435 | ma | ma |
| | | L | 29.939* | 2.336 | 27.270* | 2.482 | ma | ma |
| 2. | LBI – II | R | 43.856* | 3.332 | 41.101* | 3.497 | bm | bm |
| | | L | 42.423* | 2.886 | 41.408* | 3.263 | bm | bm |
| 3. | LBI – III | R | 47.966* | 3.270 | 46.308* | 3.245 | bch | mch |
| | | L | 47.683* | 2.406 | 46.513* | 2.701 | bch | mch |
| 4. | HBI – A | R | 93.069* | 3.642 | 91.106* | 4.065 | vwc | vwc |
| | | L | 92.650* | 3.637 | 91.200* | 4.220 | vwc | vwc |
| 4. | HBI – B | R | 69.628* | 4.194 | 68.037* | 3.867 | tekl | pekl |
| | | L | 69.934* | 4.320 | 67.085* | 3.847 | tekl | pekl |
| 6. | HBI – C | R | 63.376* | 4.053 | 62.942* | 3.810 | slst | slst |
| | | L | 63.342* | 3.830 | 62.966* | 4.534 | slst | slst |

SD – Standard deviation; * statistically significant if P<0.05; ma – mesaktin; bm – breviman; bch – brachycheir; mch – mesocheir; vwc – very weakly convergent; tekl – tetartoklin; pekl – pemptoklin; slst – sublevistrikt;

**Table 4.13: Hand Anthropometric Indices of Kumaoni Rajput from Uttarakhand**

| S.No. | Hand Indices | | K. Rajput Males (n = 6) | | K. Rajput Females (n =7) | | Hand Classification | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean | SD | Males | Females |
| 1. | LBI – I | R | 29.792* | 1.967 | 28.049* | 2.402 | ma | ma |
| | | L | 29.808* | 1.890 | 28.042* | 2.422 | ma | ma |
| 2. | LBI – II | R | 43.777* | 2.628 | 42.483* | 3.448 | bm | bm |
| | | L | 43.598* | 2.643 | 41.938* | 3.219 | bm | bm |
| 3. | LBI – III | R | 46.854* | 3.295 | 44.672* | 3.111 | mch | mch |
| | | L | 44.681* | 3.112 | 44.990* | 2.754 | mch | mch |
| 4. | HBI – A | R | 93.288* | 4.983 | 91.015* | 4.133 | vwc | vwc |
| | | L | 93.210* | 4.900 | 91.225* | 4.116 | vwc | vwc |
| 4. | HBI – B | R | 69.993* | 3.794 | 68.498* | 4.200 | tekl | pekl |
| | | L | 69.354* | 3.992 | 68.337* | 4.102 | tekl | pekl |
| 6. | HBI – C | R | 64.907* | 3.678 | 62.276* | 3.738 | slst | slst |
| | | L | 63.177* | 3.714 | 62.189* | 4.320 | slst | slst |

SD – Standard deviation; * statistically significant if P<0.05; ma – mesaktin; bm – breviman; mch – mesocheir; vwc – very weakly convergent; tekl – tetartoklin; pekl – pemptoklin; slst – sublevistrikt;

**Table 4.14: Hand Anthropometric Indices of Kumaoni Shilpkar from Uttarakhand**

| S.No. | Hand Indices | | K. Shilpkar Males (n = 6) | | K. Shilpkar Females (n =7) | | Hand Classification | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean | SD | Males | Females |
| 1. | LBI – I | R | 28.773* | 2.781 | 27.016* | 2.139 | ma | ma |
| | | L | 28.150* | 2.573 | 27.482* | 2.309 | ma | ma |
| 2. | LBI – II | R | 41.488* | 3.992 | 40.974* | 2.917 | bm | mm |
| | | L | 41.091* | 3.105 | 40.716* | 2.497 | bm | mm |
| 3. | LBI – III | R | 46.956* | 4.103 | 44.581* | 2.461 | mch | mch |
| | | L | 44.492* | 3.137 | 44.019* | 2.264 | mch | mch |
| 4. | HBI – A | R | 90.342* | 4.437 | 89.877* | 3.895 | wc | wc |
| | | L | 90.351* | 3.479 | 89.477* | 4.060 | wc | wc |
| 4. | HBI – B | R | 69.409* | 2.906 | 68.441* | 3.485 | tekl | pekl |
| | | L | 69.493* | 3.199 | 67.511* | 4.169 | tekl | pekl |
| 6. | HBI – C | R | 64.661* | 3.278 | 61.476* | 3.556 | slst | slst |
| | | L | 63.858* | 3.278 | 61.039* | 4.028 | slst | slst |

SD – Standard deviation; * statistically significant if P<0.05; ma – mesaktin; bm – breviman; mm – medioman; mch – mesocheir; wc – weakly convergent; tekl – tetartoklin; pekl – pemptoklin; mst – mediostrikt; slst – sublevistrikt;

## 5. Discussion

The investigation into anthropometric hand dimensions among the North Indian population offers significant insights that hold both forensic and anthropological value. This study aimed to explore variations in hand measurements across selected North Indian populations, taking into account socio-demographic and occupational influences. The results, presented in Tables 4.1 to 4.14, elucidate the differences and similarities within and between the population groups studied, including Gujar, Jat, Kumbhar, Kumaoni Brahmin, Rajput, and Shilpkar from Delhi, Uttar Pradesh, and Uttarakhand.

One of the notable findings is the clear indication of sexual dimorphism in hand dimensions across all population groups. Males generally exhibit larger hand dimensions than females, consistent with the findings of Aboul-Hagag et al. (2023) and Barut et al. (2023) . This distinction is crucial for forensic anthropologists, as it aids in the sex determination of dismembered or unidentified remains, echoing the utility of hand anthropometry highlighted by Kanchan and Krishan (2023) . The educational qualification and occupational level distributions also present interesting patterns, reflecting the socio-economic backgrounds of the populations studied. The disparities observed,

particularly the high percentage of illiteracy among females in certain groups, underscore the socio-cultural dynamics at play, which could influence hand usage and, consequently, hand dimensions.
Another significant aspect of this study is the variation in hand anthropometric indices, which has been used to classify hand phenotypes. These indices reveal the diversity in hand shapes within the North Indian populations, potentially offering a basis for distinguishing between ethnic or regional groups, as suggested by the work of Nidiaputri and Ardiyanto (2017) on Indonesian females . This points to the importance of considering regional and ethnic variations in hand dimensions for more accurate forensic identification.
The precision estimates of hand anthropometric measurements, as shown in Table 4.2, confirm the reliability of the data collected, with high coefficients of reliability (R) across all measurements. This precision is vital for the credibility of anthropometric data in forensic and anthropological research. It's also noteworthy how hand dimensions correlate with stature and other body metrics, supporting the findings of Kapoor et al. (2021) and Jee and Yun (2019), who reported a strong positive relationship between hand length and height . This correlation further enhances the utility of hand anthropometry in forensic science, especially in cases where other means of identification are not available.
This study aligns with the broader body of research indicating the potential of hand anthropometry not just in forensic identification but also in understanding human biological diversity. The rich dataset provided here adds to the global anthropometric database, facilitating comparisons across different populations and contributing to the development of more refined anthropological theories and forensic practices. The inclusion of hand anthropometric indices and their classification of hand phenotype enriches the discussion on ethnic and regional variations, supporting the idea that hand measurements can reflect broader human diversity. As highlighted by the literature, including works by Khadem and Islam (2020) and Mestrovic and Ozegic (2022), such variations are not merely of academic interest but have practical implications in areas ranging from forensic science to ergonomic design .
The results of this study underscore the significance of hand anthropometry in the fields of anthropology and forensic science. By providing a detailed analysis of hand dimensions across a representative sample of North Indian populations, this research contributes valuable insights into human diversity, offering tools and data that enhance our understanding of human biology and aid in forensic identification.

## 6. Conclusion

The comprehensive study of anthropometric hand dimensions among North Indian populations yields invaluable insights that bridge the gap between forensic science and anthropological research. By meticulously analyzing the variations in hand measurements across distinct socio-demographic and occupational backgrounds within the North Indian context, this study not only reinforces the concept of sexual dimorphism prevalent across human populations but also unveils the intricate socio-cultural fabric that defines and differentiates these communities. The clear disparities in hand dimensions between genders across all groups highlight the enduring value of hand anthropometry in forensic identification, particularly in scenarios involving dismembered or unidentified remains. Furthermore, the detailed examination of hand anthropometric indices and their role in classifying hand phenotypes illuminates the depth of human biological diversity, offering a nuanced understanding of ethnic and regional variations that transcend mere physical measurements and delve into the essence of human evolution and adaptation.
This research stands as a testament to the interplay between human biology, culture, and environment, showcasing how hand measurements can serve as a lens through which the tapestry of human diversity is explored and understood. It aligns with and contributes to the global body of knowledge on human anthropometry, providing a robust dataset that not only aids forensic practitioners in the identification process but also enriches the anthropological discourse on human variation. As such, it encapsulates the multifaceted nature of hand anthropometry, highlighting its significance beyond forensic application to its role in deciphering the complex narrative of human evolution, diversity,

and adaptation. In essence, this study reaffirms the value of anthropometric research in enhancing our comprehension of the human condition, emphasizing the intersection of science, culture, and history in shaping our understanding of humanity's place within the natural world.

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