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ESTIMATION OF STATURE FROM HAND AND FINGERBALL LENGTHS AMONG THE SANTHALS OF ODISHA

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Human stature estimation is vital in personal identity of medico-legal cases. Researches into it go back to the closing stages of 19th century. The limited published literature on this aspect called for the present work on 100 Santhals (M: 50, F: 50) aged 18-48 years from the Odisha village of BantaliRakhasahi in Mayurbhanj district. The male stature is 162.5 cm with the highest value found in 18-28 year age group, while that of females is 150.7 cm. The male direct/indirect and left/right hand lengths present almost similar average values of stature, ranges and multiplication factors. Differences between estimated and actual stature are higher in direct right hand length than those of left hand irrespective of age. On the other hand, the male indirect left or right hand lengths show no trend in age groupwise differences between actual and estimated stature. The female direct/indirect or left/right hand lengths for stature, ranges and multiplication factors show no remarkable differences by any age groups. The female differences between actual and estimated stature show higher direct hand lengths for either side in 39-48 year age range than the rest. The female indirect measurements of left hands show highest range of differences in 18-28 year age class between actual stature and estimated stature. The female right hand values are however of a low magnitude. In fingerball lengths, both sexes present no pattern in their direct/indirect and left/right fingerball lengths/ranges/multiplication factors. In their age groupwise differences between estimated and actual stature, however, both sexes show almost similar values between right and left hand measurements by direct method, while indirect or print measurements indicate lower ranges of differences between.

Human Stature and its Estimation Methods

The human stature or height estimation is an important dimension of forensic importance. It is a known fact that stature determines the physical identity of an individual besides identification of other traits like age, sex, ethnic group, etc. Stature estimation is made from skeleton including skeletonized remains, mutilated or amputated limbs or parts of limbs using anthropometric methods. Its significance lies in personal identification of humans involved in natural calamities like floods and earthquakes, air crashes and rail or fire accidents or of those found in wars, murders including mass murders, etc.

The history of research into the methods of estimation of stature goes back to nearly over one-and-a-quarter centuries and continued till date, while in ancient India the sages Charaka and Sushrutha were well acquainted with the relation of

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different parts of body and height by about sixth to fourth century itself. Thomas Dwight for the first time in 1884 introduced the anatomical and the mathematical or statistical methods in the estimation of stature from the proportions of certain bones to height. This was followed by Beddoe's work in 1887 predicting living stature from femoral length. During the next 14 years appeared the contributions of Rollet in 1888, Manouverer in 1892-93, K. Pearson in 1899 and Macdonnel in 1901. Of all these contributions, the one by Pearson (1899) stands out prominently owing to its significance in the reconstruction of stature of prehistoric races in the context of the evolutionary theory. Pearson used Rollett's data for creating regression formulae in the estimation of stature for which purpose he made use of long bone lengths.

From the first quarter of the 20th century however many studies were carried out on stature estimation using regression formulae: N. Pan in 1924, Stevenson in 1929, B.S. Nat in 1931, Mendes-Correa in 1932, Breitinger in 1937, A. Tetkka in 1950, Dupertius and Haddon in 1951, M. Trotter and G.C. Gles in 1951 and 1958, Oliver, G. Steele and T. Mckern—both in 1969, G. Steele in 1970, P. Badkur in 1985, Feldesman and associates in 1990, Formicola in 1993, T. Simmons and associates (RLJantz and WM Bass) in 1995, Shroff and associates in 1999, Radoinova and associates in 2002, I. Duyar and C. Pelin, and Y. Vats-all in 2003; G. Steele, and T. Mckern and Tiwari, and Nath—all in 2005; P. Jain and associates (S. Kaur and S. Nath) in 2006, Chibba and Bidmos in 2008, Mukhopadhyay and associates and Bhavana and Nath—all in 2009; B.M. Auerbach and C.B. Raff in 2010, Hawks and Kennedy in 2011 and soon.

Of all these studies, the work of Pan (1924) for the first time acquired significance due to the formulation of regression equations from the proportions of each of the long bones to stature. This formulation, arrived at a constant known as "multiplication factor" (MF), enables the estimation of stature by the multiplication of the maximum length of a long bone with the multiplication factor. This was subsequently adopted by a number of scholars like B.S. Nat, MAHSiddique and MA Shah, B Singh and HS Sohal, P Badkur, OP Jasuja and associates (M Sigh and M Jain), S Nath, Y Vats, P Jain and his associates (S Kaur and S Nath), S Hossain, S Singhal and VRao, and VKRWaghmare and his associates – all during 1931 and 2011.

Earlier Works

Earlier works relating to human stature have been carried out both in India and abroad. The Indian works consisted of those of Pan (1924) from long bones of Hindus, Nat (1931) from long bones from United Province, Siddique and Shah (1944) from long bones of Pubjabis, Singh and Sohal (1952) from the length of clavicle in Punjabis, Lal and Lala (1972) in North Bihar from lengths of ulna and tibia, Qamra *et al.* (1980) from foot measurements of an adult population of

Northwest India, Bhatnagar *et al.* (1984) among the Punjabi males from the somatometry of their hand, Anand and Nath (1990) among the Rajputs of PauriGarhwal based on their percutaneous measures of the upper and lower extremities and by the same workers in the same year from the percutaneous measurements of upper and lower limb bones of Baniya Hindu females of Delhi, Jain *et al.* (1999) among the female Jats of Delhi from their foot and shoe measurements, and Krishan and Sharma (2007), and Krishan (2008) in a North Indian population from dimensions of hands and feet, and foot and its segments respectively; and Mondal et al (2009) in living adult males of Burdwan district and adjacent areas of West Bengal using ulnar lengths, etc.

The only work made among the Indian Muslims was that by Bhavana and Nath (2009) from lower limb measurements of Shia Muslims. A few studies also have been carried out among the tribal populations of the country: by Duggal and Nath (1986) among the Lodhas and Mundas of Midnapore District of West Bengal using percutaneous lengths of ulna and radius, by Kapoor (1987) among the Lodhas of Midnapore district of West Bengal through hand length as obtained from palm prints, by Chaudhuri (1993) among the Santals, by Jain *et al.* (1999) among the Warli males of Maharashtra using upper and lower limb bone dimensions, and by Sen and Ghosh (2008) among the indigenous Rajbansis of North Bengal based on foot length and breadth respectively.

Outside India, the investigations made on stature are as under:by Trotter and Gleser (1952) from long bones of American Whites and Negroes, by Allbrook (1961) in British and East African males as known from their tibial and ulnar lengths, by Lundy (1983) from long limb bones in the South African Negroes, by Kimura (1992) from second metacarpal length in Japanese children, by Simmons *et al.* (1995) based on lengths of cervical, thoracic and lumbar segments of the spine in American Whites and Blacks, by Mendonca De (2000) from the length of long bones in a Portuguese adult population, by Ryan and Bidmos (2007) from measurements of skull in the indigenous South Africans,by Bidmos (2008) in indigenous South Africans using fragmentary femora, and by Hossain et al (2010) based on hand length and breadth of the Bangladeshi Christian Garo tribal females.

Present Study Population and its Objectives

The foregoing accounts on the earlier works of human stature are of a limited nature as compared to its social relevance. The studies made in this regard on tribal populations are few. Considering this background, the present work was undertaken among the Santhals, a homogeneous scheduled tribe inhabiting the BantaliRakhasahi village (lying on East Longitude of 85°40' and North Latitude of 21°16' and 22°34') in Mayurbhanj district of Odisha. The village is about 80 km from the district headquarter town of Baripada and about 8 km from Rairangpurtownship (Maps 1 to 3). Fifty three (53) of the 62 tribes of the state are

found in Mayurbhanj district. Over fifty percent of the tribal populations of the district constitutesSanthals. Though theirs is a multiethnic village, the Santhals are in predominant numbers.

The village has a population of 904 individuals (M: 52.5%, F: 47.5%) represented by 175 families. Of these families, 131(74.85%) consist of Santhal families. The remaining 44 families are represented by Kamila (goldsmith) (No.: 24, 13.7%), Komar (No.: 9, 5.1%), Ghasi (SC–No.: 2, 1.1%) and Gouda (milkmen–No.: 1, 0.6%) and the Munda (No.: 5, 2.9%) and Kolha (N: 2, 1.1%) tribes. Thus the Santhalspredominate other communities. Of the 687 Santhals (M: 373, F: 314), major proportions of males were found in the age groups 40-49 years (23.9%) and 30-39 years (23.6%) while in females the age groups 20-29 years (28.3%) and 30-39 years (22.9%) represented the highest proportions.

The bulk of the Santhals (59% families) lives in thatched houses. Majority (76.4%) of them use bicycles as the main mode of transport. Over 50% of the families are provided electricity. Their main drinking water source is well. They have healthcare facilities within a distance of 7-8 km besides the district hospital. They use modern appliances like radio, television, mobile phone, etc. They use different kinds of tools like plough, axe, crowbar, sickle, spade, etc. They are mainly non-vegetarians. The different types of livestock are cattle, poultry, piggery and sheep and goats. Their literacy rate is fairly higher (about 70-80%) including primary school to postgraduate levels. The bulk of the Santhals (over 80%) lives in nuclear families. Over 60% of both sexes are married and monogamy (95%) is the main type of marriage. Marriage by purchase is common among them. They are mainly agriculturists. About 50 percent of the families have two earning members. They are economically better placed with annual income ranging from Rs. 20,000 to 80,000 and above.

Racially the Santhals are an Austro-Asiatic tribe with dark brown to black skin colour, grey to brown hair colour, medium to flat nasal form and medium height. They speak Santhali dialect, which is their mother tongue besides Larka, Odiya and Hindi.

The following are the objectives of the study:

(i) To estimate stature from hand length (indirect) as obtained through palm and fingerball prints among males and females.

(ii) To estimate stature from hand length (stalion crease to duct III) for both sexes.

(iii) To delineate the differences, if any, in stature between direct and indirect methods and their evaluation.

(iv) To formulate the multiplication factors for the estimation of stature from hand length and fingerball length.

(v) To make a comparative evaluation of the findings of our study with similar other works made earlier.

Material and Methods

Sample Selection and Field work

The village of BantaliRakhasahi located in the Mayurbhanj district of Odisha was selected for the present purposes of the study as it is predominantly inhabited by the Santhal tribe. The research design was developed on the basis of a pretested study of 25 samples of the subjects. The research protocol includes different types of data covering socio-cultural, demographic and anthropometric traits.

The sample consisted of a total of 100 subjects, 50 males and 50 females. The sampled subjects were drawn randomly from 131 households. During this process, rapport was established with the subjects and accordingly they were kept informed about the actual work of the project and its purpose as also usefulness to the community. After their consent was obtained, the actual field work was commenced.

The field work was carried out by the first author in a single phase of 45 days during 1st January to 14th February 2011. During the first fortnight, basic data pertaining to ethnography and general aspects of the people and area were gathered. For collecting these data, questionnaire and schedule methods were followed apart from interview and observation methods. The rest of the period was devoted to recording relevant anthropometric measurements on the sampled males and females. At the same time their hand prints were taken.

As the main focus of the study was estimation of stature among the Santhals based on the lengths of hands and fingerballs, it became necessary to record linear measurements of stature, hand length and fingerball length. Stature was measured by Martin's anthropometer rod while the latter two types of measurements were taken by sliding caliper. These measures were taken on the subjects "directly" and hence the method used is accordingly called "direct method". The other category of length measurements included those taken on the "prints" of hands and fingerballs of the selected subjects. These measures were also taken by the sliding caliper. As these measures were taken "indirectly" on the hand and fingerball prints, the method employed is known as "indirect method".

Unlike in the case of linear measurements taken directly on the subjects using anthropometer rod and sliding caliper, in the case of print measurements of hand length and fingerball length it became necessary to obtain the prints of the respective subjects before hand by employing the following materials: plain white papers, cyclostyling/duplicating/stamp pad ink, a palmar pad, a duster pad, a glass slab, a pair of plastic gloves, a soap and a towel.

The procedures followed for taking stature, hand length and fingerball length and the instruments employed for each of them are described separately as follows.

Anthropometric Procedures

Stature – Also known as standing height or height vertex, stature of each subject was measured with the anthropometer when the subject stood erect against a wall with his/her hip and back touching the wall, the barefooted feet and heads touching each other, the arms hanging along the sides, the palms touching the thighs and the head oriented in the eye-ear or Frankfurt horizontal plane. While taking the measurement, the investigator stood on the right side of the subject, held the anthropometer vertically in the mid-sagittal plane of the subject, the crossbar fixed to the movable socket was lowered to touch the vertex gradually and recorded the reading in cms. The measurement was repeated thrice and the average of the three was taken as the final reading.

Hand length – This measurement was taken by two separate methods: direct method on the subjects concerned and indirect method on the prints of the subjects.

By the direct method, the hand length measurements of the respective subjects were taken by sliding caliper between the mid-point of a line joining the two stylions to dactylion of middle finger. For this purpose, the fixed crossbar of the caliper was placed on the line passing through the stylion at right angles to the midline of the hand known as bracelet crease. The measurement was recorded when the movable crossbar of the caliper touched the inner side of the dactylion. Before actually taking the measurement, the subject's hand was placed on a table or platform by stretching it properly.

In the case of indirect method, first, the hand (palm) print of the subject was obtained on a plain paper after applying the cyclostyling ink. Then the hand length measurement was taken by a transparent scale as the straight distance between the middle fingertip and bracelet crease.

Fingerball Length – This measurement was taken on all the fingerballs of the subjects by employing direct and indirect methods.

In direct method, the length of the fingerball was taken in cms by the sliding caliper from the tip of the respective finger and the distal phalangeal crease, when the subject's hand was fully stretched.

In indirect method, the finger tip prints of the subjects were taken by applying the cyclostyling ink with the distal phalangeal crease appearing clearly on the paper. On such prints, the straight distance from their tips to the respective crease was measured in cms with the help of a transparent scale.

Data Processing and Statistical Analysis

The data on different socio-cultural aspects of the sampled people was arranged manually on a separate sheet of paper, whereas in the case of anthropometric measurements of stature, hand and fingerball lengths of both the hands of the subjects, grouping was done by three different age classes as well as by direct and

indirect methods. The entire data was transformed to MS-Excel sheets according to separate files.

The processed data were analyzed for mean/average. For calculation of "multiplication factor", the mean values of stature and fingerball were divided by the means by hand length of both hands separately according to direct and indirect methods. Following Pan (1924), the mathematical method of formulating regression equations was employed by using the proportions of long bones to stature to derive multiplication factor (MF): MF= stature/bone measurement. These were further multiplied with the actual hand lengths of either side according to direct and indirect methods in order to obtain estimated stature. Similarly, the fingerball lengths of both hands obtained by direct and indirect methods were also multiplied by the multiplication factor and thus the stature has been recorded.

Analysis and Results

The estimation of stature in the Santhal tribal community of our study was analysed from direct and indirect hand lengths and fingerball lengths of right and left sides by age groups for males and females separately. In all cases, averages have been calculated for stature, hand length, fingerball lengths and multiplication factors. Further the multiplication factors have been calculated by dividing the average stature by the average hand lengths and fingerball lengths obtained by direct and indirect methods and for right and left hands separately by the three age classes of 18-28, 29-38 and 39-48 years.

$$\text{The formula is MF=} \frac{\text{Average Stature}}{\text{Direct or Indirect Left or Right Hand Length}}$$

Male Stature from Hand length

As shown in table 1, according to direct method the average stature value of the 18-28 years age group is relatively higher than the values of mean stature of age groups of 29-38 and 39-48 years in order, whereas the stature range of 29-38 years age group as also that of 18-28 years age group are far wider than the range of 39-48 year age group. The average values of left hand (LHL) and right hand length (RHL) of the three age groups show negligible differences as well as those of mean, ranges and multiplication factors (MF).

The indirect method also presented similar values of average stature and actual stature (Table 2) as in the case of those obtained by direct method earlier presented in Table 1. In all age groups, the values of LHL, their ranges, their multiplication factors and means are closely comparable to those of direct method. So is the case of the values of RHL, their ranges, their multiplication factors and means respectively.

Further analysis has been made to know the age groupwise differences between actual stature and estimated stature of males from direct left and right hand lengths

using multiplication factor. Stature has been estimated for each age group by multiplying the actual left and right hand lengths separately with the respective multiplication factors. For this purpose, direct hand lengths of right and left sides have been taken on five male subjects each of the three age groups to find out the differences between the actual stature and estimated stature.

The results portrayed in table 3 show differences of the highest range in the 18-28 year age class (2.6–10.4 cm) and the lowest is found in the 39-48 year age group (0.0–8.5 cm), when these were calculated between the estimated and actual stature by the multiplication of right hand lengths. Similarly, the differences between the estimated and actual stature calculated through the left hand length show a minimum value of 1.0 cm in the age groups of 18-28 and 39-48 years and 0.8 cm in 29-38 year age class, while the maximum is found in 18-28 year age group (8.6 cm). As compared to the stature differences for right hand lengths, these are much lower.

In the case of indirect left and right hand lengths also, age groupwise differences between actual stature and estimated stature of males have been reported using multiplication factor. Here too, measurements were taken on fifteen subjects, five each of the three age groups, for drawing differences between actual and estimated stature. The differences between the estimated and actual stature shown by the right hand length or that of its counterpart of the left side do not indicate any trend although the highest minimum difference of 1.5 cm is characterised by the 18-28 year age groups for right hand and the highest maximum differences of 7.4 cm occurs in the age groups of 29-38 years and 39-48 years for right hand and 29-38 years for left hand respectively (Table 4).

Female Stature from Hand Length

Following the direct method, the average values of stature, LHL, RHL and their respective MFs have been calculated (Table 5). Their values are found to show negligible inter-age group differences with the age group of 39-48 years showing the highest average stature, the age groups 18-28 years showing highest RHL and LHL, and the age group 39-48 showing highest MFs. Their corresponding lowest values lie in age groups of 29-38 and 39-48 years respectively. However the values broadly fluctuate around their means. In the matter of the actual ranges of stature, LHL and RHL, the age groups of 18-28 years and 29-38 years indicate wider variation than those of age group 39-48 years.

When the calculations have been made according to indirect method, the mean values of all the above traits have been found to be exactly similar, except in the case of LHL (18.24, 18.00 and 17.65 cm), RHL (17.86, 18.16 and 17.57 cm), their ranges (LHL: 16.7-19.7, 16.5-19.6 and 16.7-19.0 cm; RHL: 16.1-19.9, 16.6-19.5 and 16.0-18.8 cm) and their MFS (LHL: 8.26, 8.30 and 8.59; RHL: 8.44, 8.23 and 8.63) with their mean values (17.96, 16.5-19.7, 17.86, 16.0-19.9 cm and 8.38 and 8.43) fluctuating around those obtained by direct method.

For evaluating the differences by age groups between actual stature and estimated stature of females from left and right hand lengths taken by direct method, further analysis has been made using multiplication factor. The results of the analysis as presented in Table 6 reveal higher range of differences in the 39-48 years age class (1.9-5.5 cm) than those of 29-38 (0.5-3.6 cm) and 18-28 (0.3-1.6 cm) year age groups in the case of left hand. Similar trend in stature differences in observable in the case right hand too (39-48 year age group: 0.8-5.2 cm, 29-38 year age group: 0.2-5.2 cm, 18.28 year age group: 0.8-4.1 cm).

The age groupwise difference between the actual stature and estimated stature for indirect hand lengths of either side have been calculated using multiplication factor and furnished in table 7. The differences of highest range occur from 0.7 to 4.1 cm in the age class of 18-28 years followed by those of the other two age groups (29-38:1.0-2.7 cm, 39-48: 0.2-1.7 cm) for the left hand. For right hand length also differences of a low magnitude are found between the actual and estimated statures in the order of the age classes 29-38 (0.8-3.9 cm), 18-28 (0.6-2.1 cm) and 39-48 years (0.9-1.7 cm) respectively.

Stature Estimation from Fingerball Lengths

The direct and indirect lengths of the ten fingerballs, five each of the left and right hands of the male and female Santhals, were analysed by the three age groups of 18-28, 29-38 and 39-48 years for their means, ranges and multiplication factors. The mean stature values calculated earlier from hand lengths remained constant for the present purposes too. The left fingerballs are of index finger (LI), middle finger (LM), ring finger (LR), little finger (LL) and thumb (LT). Their corresponding right fingerballs are RI, RM, RR, RL and RT respectively. The digit-wise multiplication factors also have been calculated by dividing the average stature of each of the age groups by the respective fingerball lengths of either hand.

Male Stature

The combined mean values of male left hand fingerabll lengths according to direct method range from 2.4 cm for LL to 3.3 cm for LT, their respective ranges being 2.0-2.8 cm to 2.6-3.7 cm. The means of multiplication factors occur in a reverse order, from 49.2 for LT to 67.7 for LL. The individual average fingerball lengths, their ranges and multiplication factors do not show any pattern in their occurrence, when these are considered by age groups. However the three age groups (18-28, 29-38 and 39-48) generally present higher values for the first two traits (fingerball lengths and fingerball length ranges), while in the case of multiplication factors the values are generally higher in all the age groups for all digits (18-28: LI – 65.5, LM and LR – 63.0 cm, LL – 68.2; 29-38: LI – 67.6, LM and LR – 64.9, LL – 70.6; 39-48: LI and LM – 57.6, LR – 59.7, LL – 64.5).

In the case of right hand, the combined means of fingerball lengths also range from 2.4 cm for RL to 3.3 cm for RT as in the case of left hand, while their respective ranges slightly vary (2.0-2.7 cm for RL to 2.7-3.7 cm for RT). The means of multiplication factors also show a reverse order of the same magnitude as observed for the left hand (49.2 for RT to 67.7 for RL). So is the case in the matter of average fingerball lengths, their ranges and multiplication factors by age groups, that is to say, the pattern of left hand is repeated here too.

The results of the male left fingerball lengths according to indirect method are the following in comparison to those of direct method:

The combined means show lower fingerball lengths (2.1 cm for LL to 2.8 cm for LT), lower fingerball ranges (1.8–2.8 cm to 2.1–3.4 cm), higher means of multiplication factors with reverse order (58.0 for LT to 77.4 for LL), and absence of any pattern by age groups in the occurrence of individual average fingerball lengths, their ranges and multiplication factors — all with negligible variations.

The male right fingerballs by indirect method show similar fingerball lengths (2.1 cm for RL to 2.9 cm for RT), lower fingerball ranges (1.4-2.6 cm to 2.5-3.2 cm), similar higher means of multiplication factors with reverse order (56.0 for RT to 77.4 for RL), and absence of any pattern by age groups in the occurrence of individual average fingerball lengths, their ranges and MFs – all with negligible differences.

As in the case of hand length, here too attempt has been made to analyse age groupwise differences between actual stature and estimated stature of males and females from direct and indirect left and right fingerball lengths using multiplication factor. In either sex, stature has been estimated for each age group by multiplying the actual left or right fingerball lengths separately with the respective multiplication factors by direct or indirect methods. For each of the sexes, direct and indirect fingerball lengths of right and left sides, five subjects each of the three age groups have been recorded to delineate the differences between the actual stature and estimated stature.

The results of the analysis show no pattern or trend in the male age groupwise differences calculated by the direct method between the estimated and actual stature by the multiplication of left fingerball lengths: In the 18-28 year age class, the differences range from 0.1-2.7 cm for LM to 0.3-4.9 cm for LL, in the 29-38 year age group the differences range from 0.0-3.1 cm for LR to 0.2-4.7 cm for LM and in the 39-48 year age group the differences vary from 0.7-2.6 for LL to 1.4-4.7 for LR. The minimum difference ranges by age groups are represented by LM, LR and LL while their respective maximums are presented by LL, LM and LR respectively. The differences are much larger in the maximum ranges than in the minimum ranges. The male right fingerball lengths too present a disturbing trend in the differences between the actual stature and estimated stature: 0.1-2.1 cm for RT to 0.3-8.0 cm for RL in the age group of 18-28 years, 0.0-3.3 cm for RT to 0.2-

12.7 cm for RI in age group of 29-38 years and 0.9-2.7 cm for RT to 0.7-3.8 cm for RL in the age group of 39-48 years respectively. The widest minimum and maximum ranges of differences lie in the 29-38 year age group while those of the other two age classes are much lower.

For male left fingerball lengths multiplied by indirect method, the following are the age groupwise differences between the actual and estimated statures: 0.1-3.5 cm for LT to 0.0-5.9 cm for LL in the age group of 18-28 years, 0.0-2.3 cm for LL to 0.2-3.7 cm for LT in the age group of 29-38 years, and 0.0-1.2 cm for LT to 0.1-4.7 cm for LL in the age group of 39-48 years respectively. The lower ranges are represented by LT of both 18-28 and 39-48 year age groups and by LL of 29-38 year age group. On the other hand, the higher ranges are found in LL of both 18-28 and 39-48 year age groups and LT in the age group of 29-38 years. Thus LT and LL values of lower and higher stature differences indicate the trend in two of the three age groups. The indirect method has been applied for multiplication of male right fingerball lengths to assess age groupwise differences between the actual and estimated statures. The results of this analysis show extremely low minimum values ranging from 0.0 cm of 29-38 year age group to 0.4 cm of 39-48 year age group. The maximum values too fluctuate between 2.3 cm and 4.3 cm of 29-38 and 18-28 year age groups respectively. The ranges of differences are 0.2-2.8 cm for RM and RR in the age class 18-28 years, 0.0-2.3 cm for RL to 0.1-3.0 for RM in the age class 29-8 years and 0.1-3.4 cm for RL to 0.4-4.1 cm for RI and RR in the age class of 39-48 years.

Female Stature

In the female left fingerball lengths by direct method, while the age groupwise average stature values remain constant, the mean average fingerball lengths fluctuate from 2.1 cm for LL to 2.9 cm for LT with 2.3 cm each of LI, LM and LR lying between these values. Their actual ranges vary from 1.8-2.5 cm for LL to 2.1-3.9 cm for LR with the other fingerball length ranges too approximating these values (LT: 2.6-3.5 cm, LI: 2.0-3.5 cm and LM: 2.1-3.8 cm). Lastly, the multiplication factors show a wide range from 51.9 for LT to 71.7 for LL. The MFs of LI, LM and LR present similar values (65.5 each) which are closer to the highest MF of LL. The individual average fingerball lengths, their actual ranges and MFs fluctuating around their respective means show negligible variations by different age groups too.

In the case of female right fingerball lengths by direct method, the mean values of average fingerball lengths range from 2.1 cm for RL to 2.9 cm for RT with the RI, RM and RR values of 2.3 cm each occupying an intermediate position between these values as in the case of left hand mean fingerball lengths. Their actual ranges vary from 1.8-2.6 cm for RL to 2.6-3.3 cm for RT. Other fingerball length ranges, although narrow, present the same pattern as the left hand fingerballs. The

multiplication factors of this hand fingerballs too are closely comparable to those of the left hand fingerballs (50.2 for RT to 71.7 for RL and the MFs of 65.5 each for RI and RR and 62.7 for RM). This pattern holds good for age groupwise individual values, their ranges and MFs too.

The female left average fingerball length means present lower values with narrow range (1.9 cm for LL to 2.6 cm for LT), including the mean values of LM, LR and LT (2.0 and 2.1 cm each of the latter two). So is the case with their actual length ranges (1.6-2.3 cm for LL to 2.1-3.3 cm for LT), including the values of other fingerballs (LI: 1.7-2.5, LM: 1.9-2.6 cm and LR: 1.9-2.5 cm). The MFs also show wide range (57.9 for LT to 79.3 for LL), the MFs of other fingerballs also presenting equally higher values (LI: 75.3 and LM and LR each with 71.7). But the pattern of occurrence of these values and their individual averages,ranges and MFs by age groups are similar to those obtained for fingerballs of either hand by direct method.

The female mean values of right average fingerball lengths by indirect method (1.9-2.6 cm), their ranges (1.7-2.4 to 2.1-3.2 cm) and MFs (57.9-79.3) as also their individual values by age groups and the pattern of their occurrence are similar to those of the left hand.

The actual fingerball lengths of female left hand obtained by direct method show the following differences between the actual stature and estimated stature according to age groups: The lowest range of difference (0.1 cm for LM to 3.2 cm for LL) lies in the age group of 29.38 years and within the overall range of 0.1-2.2 for MM to 0.5-3.1 for LI. The highest range of difference (0.8 cm for LM to 3.7 cm for LT) is represented by the 18-28 year age group with its overall range of 0.8-3.4 cm for LM to 1.2-3.7 cm for LT and LR. The age group of 39-48 years with a range of 0.4 cm for LT and 3.4 cm for LL with its overall range of 0.4-2.1 cm for LT and 1.1-3.4 cm for LL occupies an intermediate position between the above two age groups. However all the ranges of differences are represented by narrow values.

The female right hand fingerball lengths obtained by direct method reveal low ranges of differences between the actual stature and estimated stature in all age groups: 0.5 cm for RM to 4.2 cm for RL with an overall range of 0.6-2.3 cm for RT to 1.5-4.2 cm for RL in the 18-28 year age group, 0.5 cm for RT to 4.4 cm for RL with the overall range of 0.5-3.3 cm for RT to 1.2-4.4 cm for RL in the age group of 29-38 years, and 0.4 cm for RT to 3.4 cm for RL with the overall range of 0.4-3.3 cm for RT to 1.1-3.4 cm for RL in the age group of 39-48 years. This trend indicates the minimum differences being characteristic of RT in 29-38 and 39-48 year age groups while the minimum value of 18-28 year age group is represented by RM. The maximum values in the three age groups are represented by RL.

The female left hand fingerball lengths too as in the case of female right hand fingerball lengths almost show lower minimum and maximum differences between the actual stature and estimated stature with respect to the three age groups (18-28

year age group: 0.4-3.1 cm for LT to 0.1-5.1 cm for LL, 29-38 year age group: 0.3-2.7 cm for LL to 0.4-3.3 cm for LM, and 39-48 year age group: 0.4-3.1 cm for LT to 1.1-3.8- cm for LI). The fingerballs represented are LTs for minimum difference ranges in age groups of 18-28 years and 39-48 years and LL in the age range of 29-38 years. For maximum fingerball length differences, the fingerballs represented in the three ages groups are LL, LM and LI respectively. The inter-age group differences are negligible.

The differences between the actual stature and estimated stature from female right hand fingerball lengths by indirect method are found to vary from 0.4-2.4 cm for RT to 0.4-3.3 cm for RI, RM and RR respectively in the age group of 29-38 years to 0.4-3.0 cm for RT to 0.1-5.1 cm for RL in the age group of 18-28 years, the values of 0.4-3.1 cm for RT to 1.1-4.6 cm for RL in the age group of 39-48 years occupying are intermediate position. Infact all these value ranges irrespective of age groups are characterized by negligible differences closely comparable to those presented earlier.

Discussion and Comparative Evaluation

The analysis and results of the study reveal that the mean stature of Santhal males varies in the order of 163.91 cm < 162.41 cm < 161.31 for the three age groups of 18-28 years, 29-38 years and 39-48 years respectively with an average value of 162.54 cm. The mean stature values occur in a decreasing order from the lower age group of 18-28 years to the higher age groups of 29-38 years and 39-48 years although the inter-age group variation is negligible. In the case of female Santhals, this trend in the mean stature is disturbed with the highest mean value of 151.64 cm representing the older age group of 39-48 years. Next to this value comes 150.82 cm representing the younger age group of 18-28 years. The lowest mean value of 149.56 cm represents the middle age group of 29-38 years. Here too the inter-age group stature values show negligible differences. The average female stature comes to 150.67 cm. This shows considerable difference from the stature of males (11.87 cm). Thus the Santhal males are taller than their female counterparts.

In the matter of estimation of stature among the Santhal community both male and female direct and indirect right and left hand lengths and fingerball lengths have been used by formulating multiplication factors (MFs). In the case of male right hand length by direct method, the difference between the actual height and estimated height was found to be 1.00 cm to 10 cm, while in the case of females the difference reported was from less than one cm and 5.2 cm, which is nearly one half of the male difference. On the whole, the height differences are observed to be minor. In the case indirect or print measurements, the differences between the actual stature and estimated stature are lower than those shown by direct measurements: in males the difference ranges from less than one cm to 8.6 cm, while in the females it lies between less than one cm and 3.9 cm.

For left hand length measurements taken by direct method, both the sexes presented almost similar differences in the actual stature and estimated stature as in the case of those of right hand: the male differences range between less than one cm to a maximum of 10.4 cm whereas those of females lie between less than one cm and 5.2 cm. The indirect or print method yielded lower ranges of differences in actual stature and estimated stature than those of direct method – the males showing a difference from less than one cm to 7.4 cm and the females presenting differences from less than one cm to 4.1 cm respectively.

Fingerball lengths of right hand and left hands of Santhal subjects of both sexes have been measured by direct method and indirect method, formulated multiplication factors and finally differences between the values of actual stature and estimated stature have been derived. With respect to male and female right and left hand fingerballs the differences found between the actual stature and estimated statures are furnished in tables 8 & 9.

A glance at the above tabulations reveals that the minimum male fingerball differences between the actual stature and estimated stature irrespective of sides and methods remain the same (0.1 cm) with the exception of the ring finger which is twice this value and remains the same for direct and indirect methods (0.2 cm). The maximum differences however fluctuate between 3.5 cm for thumb and 4.9 cm for little finger of left side by direct method, while the right hand fingerballs by direct method show no pattern in their differences, the lowest and highest values of differences respectively represented by thumb (3.3 cm) and index finger (12.7 cm). In the case of left indirect measures, the maximum fingerball differences range from 3.7 cm for thumb to 5.9 cm for little finger, while the other fingerball difference values approximate each other (5.6-5.8 cm). The right indirect measures show maximum difference between 3.4 cm for little finger to 5.7 cm for index finger, while the values of other fingerballs indicate no order in their occurrence.

The female fingerball differences, both of left hand or right hand according to direct or indirect methods, are generally higher in their minimum values for left and right fingerballs by direct method (left: 0.1-1.1, right: 0.1-0.4 cm) and indirect method (left: 0.3-1.1 cm, right: 0.3-0.4 cm), whereas their respective maximum values (direct left: 3.3-3.7 cm, direct right: 3.2-4.4 cm; indirect left: 3.1-5.1 cm, indirect right: 3.1-5.1 cm) are lower than the difference shown by the male fingerballs of either side and method.

Considering the findings of our work from measurements of both the hands and the 10 fingerballs of both sexes by direct and indirect methods, multiplication factors and differences between the actual stature and estimated stature in comparison to similar other studies from other parts of India and abroad, the following points emerge.

Illayperuma *et al.* (2009) studied stature estimation from hand lengths of 250 subjects of either sex and found positive correlation between height and hand length

by using regression equation to which our findings comparable. The work of Bhavna and Nath (2009) estimated stature from lower limb measurements using the multiplication factor and linear regression equation and found greater dimensions of males than females as in the case Odisha Santhals.

Other comparable works are those by Hossain *et al.* (2010) who used correlation and multiplication factor for stature prediction from hand length and breadth and found significant positive correlation with stature; by Sanli *et al.* (2005) who used multiple regression analyses for establishing relationship between hand length, foot length and stature; by Agnitrotri *et al.* (2007) who used linear and curvilinear analyses for finding a relationship between foot length and stature and reported highly significant linear regression model validating the highest values for the coefficient determination and multiple correlation coefficient; by Ozaslan *et al.* (2003) who found relationship between lower limb dimensions and stature among male and female Turks; by Singh and Phookan (1993) who, from their study of Thai males of Assam, suggested foot length to be a better indicator of stature than foot breadth; by Rani *et al.* (2011) who too, based on their study, found foot length as the best parameter for prediction of stature compared to foot breadth in either sex; by Macdonnel (1901) who, from his study of English criminals, derived regression formulae for stature estimation; by Jasuja *et al.* (1991) who estimated stature among Punjabi males by applying multiplication factors; by Jain *et al.* who found stature among Brahmin males of Kumaon by devising multiplication factors, etc.

Other important works which are worth citing in this connection are those of Giles and Hutchinson (1991) suggesting biological correlation between foot length and stature, Gordon and Buikstra (1992) from foot dimension, Qamra *et al.* (1980) from foot length or breadth, Nath *et al.* from foot length, Jain *et al.* from hand length, Krishan and Sharma (2007) from hand and foot dimensions, Grivas et al (2008) from foot length, Kumar (2008) from finger length, Duyar and Pelin (2010) from ulna length, Kimura (1992) from second metacarpal length, and so on. The findings of all these investigations broadly support the results of our work.

TABLE 1: AGE GROUPWISE DISTRIBUTION OF MEANS OF MALE AVERAGE STATURE, LEFT/RIGHT HAND LENGTHS AND MULTIPLICATION FACTORS BY DIRECT METHOD

				Left Hand (Direct Method)			*Right Hand (Direct Method)*		
S. No.	*Age Group (Years)*	*Avg. Stature (cm)*	*Stature Range (cm)*	*Avg. LHL (cm)*	*Range of LHL (cm)*	*MF*	*Avg. RHL (cm)*	*Range of RHL (cm)*	*MF*
1	18-28	163.91	155.5- 178.0	19.79	18.2-21.9	8.28	19.81	18.3-22.3	8.27
2	29- 38	162.41	147.7- 177.7	19.28	17.6-21.2	8.42	19.22	17.4-21.0	8.45
3	39-48	161.31	157.3-164.7	19.95	19.0-21.3	8.04	19.81	19.0-21.1	8.14
Mean		162.54	147.7-178.0	19.67	17.6-21.9	8.26	19.61	17.4-22.3	8.28

TABLE 2: AGE GROUPWISE DISTRIBUTION OF MEANS OF MALE AVERAGE STATURE, LEFT/RIGHT HAND LENGTHS AND MULTIPLICATION FACTORS BY INDIRECT METHOD.

				Left Hand (Indirect)			*Right Hand (Indirect)*		
S. No.	*Age Group (Years)*	*Avg. Stature (cm)*	*Actual Stature Range (cm)*	*Avg. LHL (cm)*	*Actual Range of LHL (cm)*	*MF*	*Avg. RHL (cm)*	*Actual Range of RHL (cm)*	*MF*
1	18-28	163.91	155.5- 178.0	19.57	18.1-21.0	8.37	19.37	17.8-21.5	8.46
2	29- 38	162.41	147.7- 177.7	18.87	17.4-20.7	8.60	18.93	17.2-21.0	8.57
3	39-48	161.31	157.3-164.7	19.68	18.1-21.5	8.19	19.08	19.1-20.7	8.45
	Mean	162.54	147.7-178.0	19.37	17.4-21.5	8.38	19.12	17.2-21.5	8.49

TABLE 3: AGE GROUPWISE DISTRIBUTION OF DIFFERENCES BETWEEN ACTUAL STATURE AND ESTIMATED STATURE OF MALES FROM DIRECT LEFT AND RIGHT HAND LENGTHS

Age Group (Years)	*Actual Stature (cm)*	*Actual Hand Length (cm)*		*Estimation of Stature (cm)*		*Differences (cm)*	
		Left	*Right*	*Left*	*Right*	*Left*	*Right*
18-28	158.0	19.7	19.5	163.1	161.2	5.1	3.2
	161.7	18.5	18.3	153.1	151.3	8.6	10.4
	163.9	20.4	20.2	162.9	167.0	1.0	3.1
	166.5	19.4	19.2	160.6	158.7	5.9	7.8
	168.5	20.7	20.7	171.3	171.1	2.8	2.6
29-38	153.4	18.7	18.5	157.4	156.3	4.0	2.9
	162.2	18.8	18.8	158.2	158.8	4.0	3.4
	164.0	20.1	20.5	169.2	173.2	5.2	9.2
	173.3	19.8	19.5	166.7	164.7	6.6	8.6
	177.7	21.2	20.8	178.5	175.7	0.8	2.0
39-48	157.3	19.7	19.3	158.3	157.1	1.0	0.2
	158.6	19.2	19.0	154.3	154.6	4.3	4.0
	162.5	20.2	19.8	162.4	161.1	0.9	0.4
	163.2	21.3	21.1	171.2	171.7	8.0	8.5
	168.4	20.6	20.7	165.6	168.4	2.8	0.0

TABLE 4: AGE GROUPWISE DISTRIBUTION OF DIFFERENCES BETWEEN ACTUAL STATURE AND ESTIMATED STATURE OF MALES FROM INDIRECT LEFT AND RIGHT HAND LENGTHS

Age Group (Years)	*Actual Stature (cm)*	*Indirect Hand Length (cm)*		*Avg. Estimation of Stature (cm)*		*Differences (cm)*	
		Left	*Right*	*Left*	*Right*	*Left*	*Right*
18-28	158.0	19.4	19.5	162.3	164.9	4.3	6.9
	161.7	18.8	18.3	157.3	154.8	4.4	6.9
	163.9	19.4	19.2	162.3	162.4	1.6	1.5
	166.5	19.7	19.2	164.8	162.4	1.7	4.1
	168.5	20.2	20.1	169.0	170.0	0.5	1.5
29-38	153.4	18.7	18.0	160.8	154.2	7.4	0.8
	162.2	19.3	19.3	165.9	165.4	3.7	3.2
	164.0	19.8	20.0	170.2	171.4	6.2	7.4
	173.3	20.7	20.1	178.0	172.2	4.7	1.1
	177.7	20.5	20.0	176.3	171.4	1.4	6.3
39-48	157.3	19.7	19.5	161.3	164.7	4.0	7.4
	158.6	19.4	18.9	158.8	159.7	0.2	1.1
	162.5	19.7	19.5	161.3	164.7	1.2	2.2
	163.2	19.7	19.1	161.3	161.3	1.9	1.9
	168.4	20.2	19.6	165.4	165.6	3.0	2.8

TABLE 5: AGE GROUPWISE DISTRIBUTION OF MEANS OF FEMALE AVERAGE STATURE, LEFT/RIGHT HAND LENGTHS AND MULTIPLICATION FACTORS BY DIRECT METHOD

				Left Hand (Direct Method)			*Right Hand (Direct Method)*		
S. No.	*Age Group (Years)*	*Avg. Stature (cm)*	*Actual Stature Range (cm)*	*Avg. LHL (cm)*	*Actual Range of LHL (cm)*	*MF*	*Avg. RHL (cm)*	*Actual Range of RHL (cm)*	*MF*
1	18-28	150.82	142.0-161.3	18.36	17.1-19.8	8.21	18.35	16.7-20.0	8.21
2	29- 38	149.56	139.2-157.0	18.34	16.5-19.7	8.15	18.32	16.5-20.0	8.16
3	39-48	151.64	146.8-157.0	17.81	16.6-19.3	8.51	17.77	16.8-19.0	8.53
	Mean	150.67	139.2-161.3	18.17	16.5-19.8	8.29	18.14	16.5-20.0	8.3

TABLE 6: AGE GROUPWISE DISTRIBUTION OF DIFFERENCES BETWEEN ACTUAL STATURE AND ESTIMATED STATURE OF FEMALES FROM DIRECT LEFT AND RIGHT HAND LENGTHS

Age Group (Years)	*Actual Stature (cm)*	*Actual Hand Length (cm)*		*Avg. Estimation of Stature (cm)*		*Differences (cm)*	
		Left	*Right*	*Left*	*Right*	*Left*	*Right*
18-28	142.0	17.5	17.2	143.6	141.2	1.6	0.8
	147.8	17.9	17.8	146.9	146.1	0.9	1.7
	148.7	18.2	18.0	149.4	147.7	0.7	1.0
	156.2	19.0	19.3	155.9	158.4	0.3	2.2
	166.6	20.1	19.8	165.0	162.5	1.6	4.1
29-38	139.2	17.3	17.2	139.0	140.3	0.2	1.1
	141.3	16.9	17.3	137.7	141.1	3.6	0.2
	151.2	18.2	17.9	148.3	146.0	2.9	5.2
	155.3	19.0	18.9	154.8	154.2	0.5	1.1
	164.5	19.9	20.0	162.1	163.2	2.4	1.3
39-48	148.2	17.7	17.5	150.6	149.2	2.4	1.0
	150.0	17.4	17.5	148.0	149.2	2.0	0.8
	152.7	17.3	17.3	147.2	147.5	5.5	5.2
	154.6	18.4	19.0	156.5	156.9	1.9	2.3
	157.0	18.8	18.8	159.9	160.3	2.9	3.3

TABLE 7: AGE GROUPWISE DISTRIBUTION OF DIFFERENCES BETWEEN ACTUAL AND ESTIMATED STATURE OF FEMALES FROM INDIRECT LEFT AND RIGHT HAND LENGTHS

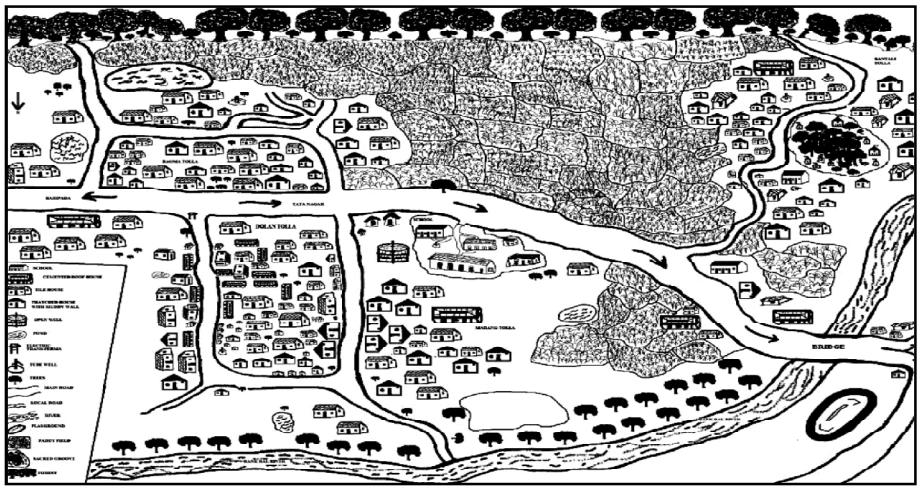
Age Group (Years)	*Actual Stature (cm)*	*Actual Hand Length (cm)*		*Avg. Estimation of Stature (cm)*		*Differences (cm)*	
		Left	*Right*	*Left*	*Right*	*Left*	*Right*
18-28	142.0	17.1	16.9	141.2	142.6	0.8	0.6
	147.8	17.4	17.3	143.7	146.0	4.1	1.8
	148.7	17.7	17.5	146.2	147.7	2.5	1.0
	156.2	19.0	18.7	156.9	157.8	0.7	1.6
	166.6	19.8	19.5	163.5	164.5	3.1	2.1
29-38	139.2	16.5	16.6	136.9	136.6	2.3	2.6
	141.3	16.9	17.5	140.2	144.0	1.1	2.7
	151.2	17.9	17.9	148.5	147.3	2.7	3.9
	155.3	18.5	18.4	153.5	151.4	1.8	3.9
	164.5	19.7	19.9	163.5	163.7	1.0	0.8
39-48	148.2	17.6	17.3	147.4	149.2	0.8	1.0
	150.0	17.7	17.5	148.3	151.0	1.7	1.0
	152.7	18.2	17.6	152.5	151.8	0.2	0.9
	154.6	18.5	18.1	155.0	156.2	0.4	1.6
	157.0	18.7	18.4	156.7	158.7	0.3	1.7

TABLE 8: MALE FINGERBALL DIFFERENCES IN CM BETWEEN ACTUAL STATURE AND ESTIMATED STATURE

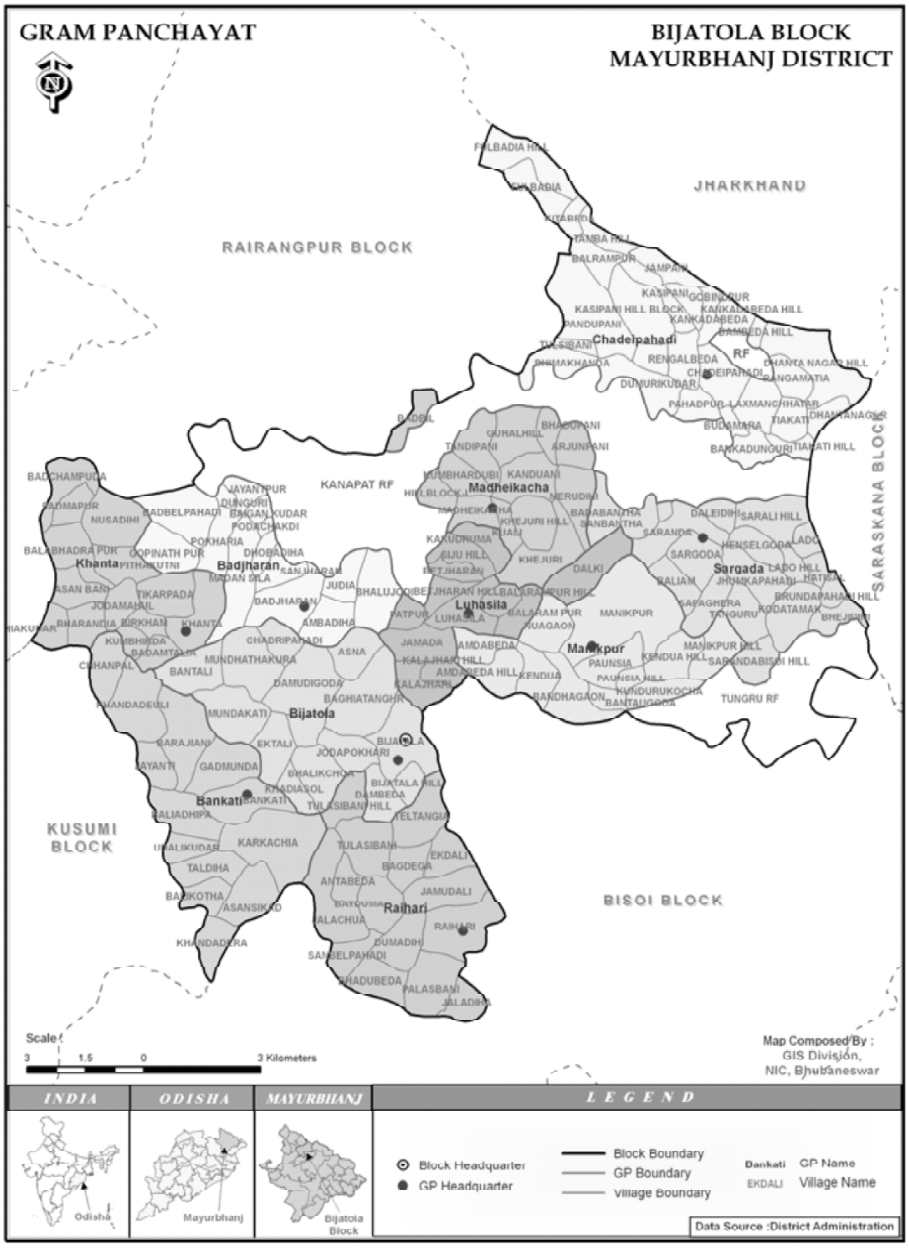
Fingerball	*Direct Method*		*Indirect Method*	
	Left Hand	*Right Hand*	*Left Hand*	*Right Hand*
Thumb	0.1-3.5	0.1-3.3	0.1-3.7	0.1-3.5
Index Finger	0.2-4.4	0.2-12.7	0.1-5.7	0.1-5.7
Middle Finger	0.1-4.7	0.1-5.0	0.1-5.6	0.1-3.8
Ring Finger	0.1-4.7	0.1-4.0	0.1-5.8	0.1-4.8
Little Finger	0.1-4.9	0.1-8.0	0.1-5.9	0.1-3.4

TABLE 9: FEMALE FINGERBALL DIFFERENCES IN CM BETWEEN ACTUAL STATURE AND ESTIMATED STATURE

Fingerball	*Direct Method*		*Indirect Method*	
	Left Hand	*Right Hand*	*Left Hand*	*Right Hand*
Thumb	0.2-3.7	0.4-3.3	0.4-3.1	0.4-3.1
Index Finger	0.5-3.3	0.4-3.4	0.3-4.6	0.4-4.2
Middle Finger	0.1-3.3	0.4-3.2	0.4-4.2	0.4-4.0
Ring Finger	1.1-3.3	0.4-3.4	1.1-4.2	0.4-4.2
Little Finger	1.1-3.4	0.1-4.4	0.3-5.1	0.-5.1



Map 1: Village Map of Bantali Rakhasahi



Map 2: Gram Panchayat of Bijatola Block, Mayurbhanj District

Map 3: Indicating Rairangpur Township and Bijatola Block in Mayurbhanj District

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