Original Research Article

Estimation of height from the lengths of second and fourth digits of hand in Gujarat region

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ABSTRACT

Introduction: Estimation of stature for personal identification forms a very important criteria in cases of incomplete skeletal and decomposed human parts. It is considered to be important in those cases where only fragmentary or mutilated remains of an unknown person are recovered as in murders, accidents, catastrophic events causing mass deaths from natural disasters. In the present study, the attempt has been made to correlate 2nd and 4th digits length with stature and derive a regression equation to calculate stature from 2nd and 4th digits length.

Materials and Methods: A cross sectional sample of 500 (230 males & 270 females) asymptomatic healthy students between the age group of 18-24 years belonging to Gujarat were selected to measure height and correlate 2nd and 4th digits length with height ; from which we derive a regression equation to calculate height from 2nd and 4th digit length.

Results: In present study the mean height of male and female is 163.48cm. The mean length of 2nd right is 6.99cm and that of 2nd left digit is 7.18cm. The mean length of 4th right digit is 7.15cm and that of 4th left digit is 7.11cm. Coefficient of variation of height is 5.34, of right 2nd digit is 6.90, of right 4th digit is 7.29, left 2nd digit is 7.63 and left 4th digit is 7.46.

Conclusion: It is concluded that length of digits can provide good reliability in estimation of stature. From this study we can derive simple linear regression equation for estimation of height. Simple linear regression equation is found to be one of the essential tools in Medico Legal investigations and in anthropometry.

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1. Introduction

Estimation of stature for personal identification forms a very important criteria in cases of incomplete skeletal and decomposed human parts.[1] Personal identification means determination of individuality of a person. The primary characteristics of identity are age, sex and height.[2] Stature is considered as natural height of a person in upright position. It is maximum between the age group of 20-25 years.[3] It is found that there is a close relationship between the height of the person and various parts of body like head, trunk and lengths of upper and lower limbs;[4?] estimate of which is considered to be important in those cases where only fragmentary or mutilated remains of unknown persons are recovered.[5] Similar type of study has been done on cadavers in past. But limitation is population cannot be represented by cadavers. Most of the times cadavers are of those persons who are aged and suffered from chronic debilitating diseases. Again it is found that cadavers are of persons who have been dying in an abnormal posture and therefore it is very difficult to straighten the body to get accurate stature measurement.[6] In recumbent posture height is increased by 2.5cm after death. Because of constrains mentioned above of cadaveric study, we selected living persons to conduct this study. Although there is strong relationship between body parameters that have been determined, it has been found that the r e is high variation in parametres from population to population and ethnic origin because of differences in nutrition and levels of physical activity.[7] Therefore the present study is conducted in the living adults.

We can use alternate parameter (digit length) to measure height which is not possible to measure in cases of age

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related loss in stature, deformity like kyphosis, scoliosis, lordosis contracture and missing legs.[8] The study aims to carry out the relationship between height and 2nd and 4th digits length in living subjects of Gujarat region, to derive a population specific formula (regression equation) to estimate height from 2nd and 4th digit length. We can come to know the probable height of an individual by 2nd and 4th digit length using regression analysis.

2. Materials and Methods

Institutional review board has approved my study. A cross sectional sample of 500 (230 males and 270 females) asymptomatic healthy students between age group of 18-24 years belonging to Gujarat region were selected.

2.1. Methods of collection of data

All the study subjects were given adequate information about the study and informed consent is taken. The study method was approved by the institutional review board. We have measured all the parameters in ventilated room during the time between 2:00pm to 5:00pm to avoid diurnal variation. It was measured and recorded only by us. Height, right and left 2nd and 4th digit length of each individual were recorded.

Person having significant disease or deformity that could have affected the general or bony growth are excluded.

Landmarks and techniques involved in taking anthropometric measurements:

2.1.1. Height
Standard anthropometer was used to measure height. The person was asked to stand erect on horizontal plane with eyes looking forward, palms of hands turned inwards and fingers pointing downwards and vertical distance from vertex to floor is measured.

2.1.2. **Digit length**
Sliding caliper was used to measure the digit length. The subjects were asked to place their hands supine on a flat hard horizontal surface with fingers extended. It is a linear distance between the proximal crease of digits and the distal end of the most anterior projecting point, i.e., tip of the finger.

2.2. Measurements

Stature (Height) and digit length are measured in centimetres.

Statistical Analysis done by:

1. Simple Linear regression equation........Y=a + bX

Where,
    Y= Height of Individual

a = Intercept
b = Regression Coefficient
X = Digit Length

2.3. Outcome Measures

1. Relationship between person's height and digit length in living subject.
2. Derive a population specific formula to estimate height from digit length.

Statistical Methods used for this study include Mean, Standard deviation, and Standard error of mean, Correlation of coefficient, Regression coefficient, Value of constant and 't' test.

Fig. 1: Sliding Caliper

2.3.1. Correlation coefficient (r)
The extent or degree of relationship between two sets of figures is measured in terms of other parameters called Person's Correlation coefficient. It is denoted by letter ' r '.

$$r = \frac{n(\sum xy) - (\sum x)(xy)}{\sqrt{\left[n\sum x^2 - (\sum x)^2\right]\left[n\sum y^2 - (\sum y)^2\right]}}$$

2.3.2. Regression coefficient (b):
Regression coefficient of Y on X is denoted as byx and that of X on Y as bxy.

$$byx = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sum x^2 - \frac{(\sum x)^2}{n}}$$

$$bxy = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sum y^2 - \frac{(\sum y)^2}{n}}$$

2.3.3. Value of constant (a)
It is denoted by ' a '. It is intercept of Regression line. It is derived from as:

$$a = \bar{Y} - b\bar{X}$$

Simple linear Regression formula: Y = a+bX
    Y = Height
    X = Length of Right or Left hand digit
    a = Intercept/ constant
    b = Regression coefficient
    Y_1 = a + bX_r (Right)
    Y_2 = a + bX_l (Left)

Table 1: Descriptive statistics of parameters studied in Male

Sr. No	Variable	Height (cm)	Right2nd Digit (cm)	Right4th Digit (cm)	Left2nd Digit (cm)	Left4 th Digit (cm)
1	Minimum	155	5.9	6.2	4.4	6.2
2	Maximum	185	8.4	8.6	8.4	8.6
3	Mean/ Average	170.04	7.30	7.48	7.39	7.44
4	Standard Deviation (SD)	6.07	0.40	0.42	0.47	0.43
5	Coefficient of Variation (CV)	3.56	5.52	5.70	6.42	5.81

Table 2: Descriptive statistics of parameters studied in female

S. No	Variable	Height (cm)	Right2nd Digit (cm)	Right4th Digit (cm)	Left2nd Digit (cm)	Left4th Digit (cm)
1	Minimum	136	5.9	5.9	5.9	5.9
2	Maximum	176	7.8	8.1	7.8	7.9
3	Mean/ Average	157.12	6.69	6.82	6.75	6.78
4	Standard Deviation (SD)	5.72	0.34	0.38	0.36	0.40
5	Coefficient of Variation (CV)	3.64	5.14	5.63	5.42	5.91

Table 3: Person's correlation coefficient in males

S. No.	Independent Variable	Right Hand2nd Digit	Right Hand4th Digit	Left Hand2nd Digit	Left Hand4th Digit
1	Correlation Coefficient (r)	0.100	0.548	0.14	0.53
2	Coefficient of Determination (r^2)	0.01	0.29	0.019	0.28
3	Regression Coefficient (b)	1.51	7.79	1.90	7.50
4	Intercept (a)	158.95	111.67	155.98	114.13

Table 4: Person's correlation coefficient in females

S.No.	Independent Variable	Right Hand2nd Digit	Right Hand4th Digit	Left Hand2nd Digit	Left Hand4th Digit
1	Correlation Coefficient (r)	0.319	0.594	0.308	0.466
2	Coefficient of Determination (r^2)	0.101	0.352	0.094	0.217
3	Regression Coefficient (b)	5.31	8.82	4.81	6.65
4	Intercept (a)	121.57	96.83	124.59	111.9

Table 5: Regression analyses for prediction of height in all cases

Simple Linear Regression Formula	Males and Females (500) For Right Hand	For Left Hand
Y = a + bX	$Y_{r-2} = 91.12 + 10.34X_{r-2}$	$Y_{l-2} = 160.28 + 0.44X_{l-2}$
Y = a + bX	$Y_{r-4} = 72.05 + 12.78X_{r-4}$	$Y_{l-4} = 78.72 + 11.91X_{l-4}$

Where, Y = Height
X_{r-2} = Right hand 2nd digit length
X_{r-4} = Right hand 4th digit length
X_{l-2} = Left hand 2nd digit length
X_{l-4} = Right hand 4th digit length

Fig. 2: Standard height measuring instrument

Fig. 3: Measurement of stature

3. Result

The observations and statistical outcomes of the study are presented in the tables.

Value of Correlation coefficient (r) in male: Height and right 2nd digit & height and 4th digit length is 0.100 and 0.548 respectively. Height and left 2nd digit & height and 4th digit length is 0.140 and 0.5 30 respectively.

Value of Correlation coefficient (r) in female: Height and right 2nd digit & height and 4th digit length is 0.319 and 0.5 94 respectively. Height and left 2nd digit & height and 4th digit length is 0.308 and 0.466 respectively.

4. Discussion

In addition to the various linear measurements efforts have been made by various workers to find out Correlation between height and digits' length in different regions. The present study deals with the observation on correlation of height (stature) with 2nd and 4th digits length in Gujarat region.

The height of an individual mainly being genetically predetermined is an inherent characteristic, the estimate of

which is considered to be an important in the identification of unknown human remains. [9]

Height estimation formulae based on digit length shows similar level of accuracy for calculation based on the length of other long bones. [10] We selected these criteria because compared to other bones of the body; it is easier to get more accurate measure of digit length in living subjects. The values have become increasingly important in the identification of persons.

The result of the present study shows that the dimensions of the digits can successfully be used for estimations of stature by law enforcement agencies and forensic scientists. The only precautions to be taken into consideration is that these formulae are applicable to the population from which the data has been collected, due to inherent population variation in these dimensions, which may be attributed to genetic and environmental factors like climate, nutrition etc.

All parameters showed statistically significant positive correlation with height in the present study and thus can be successfully utilized for height estimation. The presence of a positive linearity between the study variables and the height facilitates formulation of regression equation in this

population.

4.1. Regression analysis

In the present study, regression analysis for prediction of height in males and females from length of 2nd and 4th digits are as following:

Formula – Y1 = a + bXr

Male (right hand): 2nd digit- $Y_{r-2} = 158.95 + 1.51X_{r-2,}$ 4th digit- $Y_{r-4} = 111.67 + 7.79X_{r-4}$

Female (right hand): 2nd digit- $Y_{r-2} = 1\ 21.57 + 1.51X_{1-2}$

4th digit- $Y_{r-2} = 96.83 + 8.82X_{r-4}$

Formula – Y 2 = a + bX_l

Male (left hand), 2nd digit- $Y_{l-2} = 155.98 + 1.90X_{l-2}$ 4th digit- $Y_{l-4} = 114.13 + 7.50X_{l-4}$

Female (left hand), 2nd digit- $Y_{l-2} = 124.59 + 4.81X_{l-2}$ 4th digit- $Y_{l-4} = 111.94 + 6.65X_{l-4}$

Where, Y = Height

X_r -2 = Right hand 2nd digit length

X_{r-4} = Right hand 4th digit length

X_{l-2} = Left hand 2nd digit length

X_{l-4} = Left hand 4th digit length

a = Intercept / Constant

b = Regression Coefficient

Gayathri et al[11] stated that digit length displays a significant fraction in height estimation in the region of South India. According to her study value of Correlation Coefficient (r) is as following:

In male- Height and right 2nd digit & height and 4th digit length is 0.55 0 and 0.488 respectively. Height and left 2nd digit & height and 4th digit length is 0.577 and 0.465 respectively.

In female- Height and right 2nd digit & height and 4th digit length is 0.57 0 and 0.531 respectively. Height and left 2nd digit & height and 4th digit length is 0.575 and 0.399 respectively.

This study has succeeded in establishing stature estimation from digit length for population in coastal region of South India. The study provides useful parameter in forensic investigation as well as in ergo design application of hand tools and devices. If we compare data of present study and Gayathri et al, results are variable as studies were done in different regions.

Suseelamma et al[12] studied correlation between stature and length of fingers. According to her study height and length of the hand were significantly more in males compared to females, a direct relationship was observed in both sexes. The difference in right and left side measurements are minimal and statistically insignificance in derivation of regression equation. Among the five fingers middle finger will give the exact height of the individual. The regression equation for reconstruction of stature from length of the finger is

y = Bo + B_1 x

Bo = Measuring height,

B1x = Calculated height

Raju GM et al[13] focused on estimation of stature from the length of the index and ring finger of right hand both in males and females. According to his study Correlation coefficient in m ales and females are as following:

In male value of r for right index and ring finger is 0.57 and 0.45 respectively whereas in female value of r for right index and ring finger is 0.54 and 0.42 respectively.

The results of the this study indicate that the index and ring finger length can be efficiently used for estimation of stature. The study concluded that the RFL can be used with high significant values for estimation of stature in South Indian population even if only hand is found.

5. Conclusion

't' test for regression coefficient was found to be statistically significant. It suggests that a significant contribution of digits length is there towards height. The height is more if the digit length is more. So we can conclude that height is directly proportional to the digit length. 't' test for regression coefficient was found to be significant. So we can derive regression formulae for people of Gujarat as written in discussion. If either of the measurement is known, other can be calculated. This fact will be of practical use in medicolegal investigations and in anthropometry.

6. Source of funding

None.

7. Conflict of interest

None.

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