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Estimation of Height (Stature) From Inferior Extremity Length and Foot Length in Children.

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Research Article

Abstract: Personal identification is an integral part of the investigation in cases of mass disasters where disintegrated and amputated body organs are found very frequently. Estimating stature from various parameters based on the above mentioned evidences becomes one of the most important and essential exercise for personal identification. Different anthropometric parameters have been measured of 1120 children (576 male children, 544 female children) of the age group ranging from Birth to 5 years. Among these findings, height, inferior extremity length and foot length have been evaluated for sexual dimorphism as well as subjected to statistics to study the correlation of inferior extremity length and foot length with that of height. There is scarcity of literature suggesting stature estimation in this age group hence, further the regression equations have been drawn from the data collected. It has been observed that stature can be estimated from the inferior extremity length and foot length. The Technical Error of Measurements was within the accepted limits. It is determined that there was significant differences ($p<0.05$) in stature, inferior extremity length and foot length between sexes. Stature, inferior extremity length and foot length are positively and significantly correlated with each other ($p<0.01$).

Keywords: stature, foot length, inferior extremity length, children, personal identification

Introduction:

Determination of sex and estimation of stature from incomplete skeleton as well as from decomposing bodies is the burning issue in forensic science. This has mass application in recent era because of mass disasters like bomb blasts, tsunamis, earthquake, plane crash, mass suicide, forest fires.

It is well known that trunks and limbs exhibit consistent ratios among themselves and to total body height. The ratios between body segments are age, sex and race dependent (Meadows, 1996[1]; Meadows & Jantz, 1999[2]; Williams et al., 2000[3].

This relationship of different body parts is used to establish the sex as well as stature of an individual (Ebite *et al*., 2008)[4]. This is also very useful anthropologically to find the racial differences, and medico legally, when only parts of the deceased body are available. Estimation of height of an individual has obvious significance in the personal identification. As height is fundamental to assessing growth and nutrition, calculating body surface area, and predicting pulmonary function in childhood (Gauld et al., 2004)[5].

However, a number of common disabilities and disease processes make it difficult to accurately measure standing height in many patients (Auyeung et al., 2009)[6].

The majority of old methods of estimating stature are limited to measuring whole limb bone and correlating living stature and limb bone length. But few studies are reported in which an attempt has been made to estimate stature from fragmentary or mutilated parts of the body. Studies on the estimation of stature from the skeletal remains or from the mutilated limbs, mostly of the long bones have been reported as indicated by the published work of the Pearson (1899)[7], Trotter and Glesser (1952)[8]. The Indian perspective of the problem of stature estimation has been studied by the Athwale et al (1963)[9], Patel et al (1964)[10], Joshi et al (1964,65)[11], Lal and Lala (1972)[12], Kalte and Bansal (1974)[13], Thakur and Rai (1987)[14], Saxena (1984)[15], Bhatnagar et al (1984)[16], Jasuja (1987)[17].

Also there are few studies in which stature is estimated from inferior extremity length and foot length. (Agnihotri A.K. et al(2007)[18], Ozden H et al(2005)[19], Sangli S.G. et al (2005)[20],

Oommen A. et al (2005)[21], Krishnan K.(2007)[22], Patel et al (2007)[23].

Among the literature which has searched, there is scarcity of such literature availability in relation to pediatric age group. And hence this information will be highly important to Forensic scientists, human biologists and physical anthropologists for determination of stature from the fragmentary remains of lower limbs of children.

Material and Methods:

1120 children (576 male children, 544 female children) of the age group ranging from Birth to 5 years were examined for different anthropometric norms with informed consent.

This work was carried out at the well baby clinic of the Department of Pediatrics and immunization OPD of department of PSM at

Medical College Hospital, and at different primary schools of Municipal Corporation". Studies on the new born were carried out in the maternity wards of the Medical College Hospital.

The information regarding the exact date of birth was obtained from the hospital and school records and also from the records available with the parents. All measurements were done personally. Those born premature, congenital malformations or diseased children and newborn having birth weight less than 2000 gm were excluded from the study. As the study was carried on the city population which lacks in socioeconomic homogeneity, the analysis did not take into account the socio-economic status. Only apparently normal, healthy infants and children were selected for the study.

1) **Height:**

Recumbent length (Crown-heel) was recorded for babies up to 2 years.

The child was placed supine on the "Fiberglass osteometric board"; the head firmly kept in position against the upright fixed head board; the legs straightened, turning the feet to right angles with the legs keeping the toes upwards. The free foot board was brought into firm contact with the child's foot and the reading was taken to fraction of centimeter, from the scale set into the measuring table. Standing height was measured in cases of children from 2 years to 5 years.

The subject is made to stand erect and barefooted on a level ground or platform with the heels together and arms hanging. The occiput, shoulders, buttocks and heels are in the same plane and perpendicular to the ground. The head is so held that the eyes are directed on the horizon. The anthropometric rod is held either in front or back of the subject ensuring that it is perfectly vertical and parallel to the mid-sagittal plane. The cross-arm of the instrument is gently brought down to touch the vertex. Measurements were recorded to the nearest of 0.1cm.

2) **Length of inferior extremity**: This distance was measured from the tip of anterior superior iliac spine to the medial border of sole vertically below the tip of medical malleolus.
3) **Foot length**: It was measured with osteometric board. The distance between prominent points of heel to the tip of great toe was recorded.

Results:

Table I shows, the mean height *(HT)*, inferior extremity length *(IEL)* and foot length *(FL)* of the study subjects were significantly different between the genders. Statistical analysis indicated that variation was significant for the measurements of HT, IEL, FL in both sexes. Z value more than 1.96 is statistically significant.

Table I: shows the mean height (Ht), mean inferior extremity length (IEL) and Foot length (FL) of male and female children in the age group of at birth to 5 years.

Age		Mean Height			IEL			FL	
	Male	Female	Z value	Male	Female	Z value	Male	Female	Z value
At birth	48.41	45.8	8.37	21.37	29.65	20.14	7.75	7.48	18.55
Upto 3mths	60.86	57	13.40	24.43	23.01	4.45	8.84	8.44	8.69
3-6 mths	62.25	63	2.54	28.11	27.08	4.24	10	9.43	4.24
6-9 mths	67.23	65.16	7.02	30.82	29.94	5.60	10.82	10.24	5.6
9-12	70.37	69.09	4.33	32.67	31.32	4.93	11.3	10.8	5.21

mths									
1yr +	74.00	72.79	8.70	35.98	36.44	3.35	12.38	12.04	10.69
2yr+	80.60	80.32	2.07	42.24	41.06	10.48	14.08	13.81	10.48
3yr+	88.60	87.76	6.56	48.7	47.07	9.65	15.5	14.99	9.65
4yr+	95.13	94.18	6.68	53.47	52.47	9.34	16.27	15.87	9.34

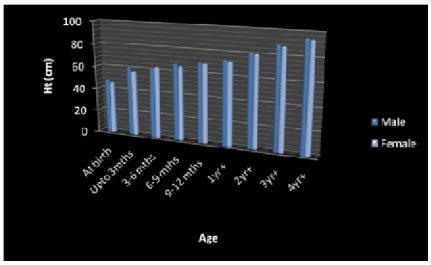

Figure I: *shows the mean height (Ht), of male and female children in the age group of at birth to 5 years.*

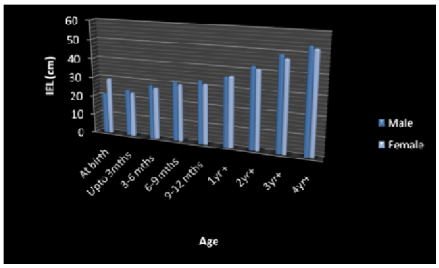

Figure II: *shows the mean inferior extremity length (IEL) of male and female children in the age group of at birth to 5 years.*

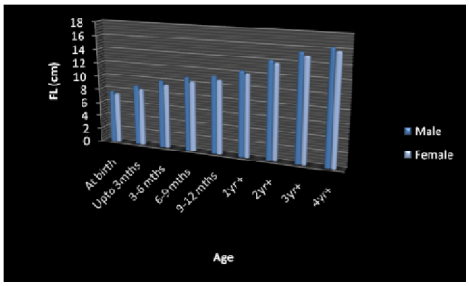

Figure III: *shows the mean Foot length (FL) of male and female children in the age group of at birth to 5 years.*

Table II: *shows the* ***correlation coefficient*** *between height and inferior extremity length and foot length is positive, suggesting that it is significant.*

	Height			
	Male		Female	
	Cor. Coe.	***P Value***	***Cor. Coe.***	***P value***
IEL	0.990	0.00	0.937	0.00
FL	0.968	0.00	0.950	0.00

Pearson's correlation coefficient was used to examine the relationship between, height and inferior extremity length and that of foot length in male and in female children. Correlation coefficient among them was found to be statistically significant P=0.00 and positive in both males and females (Table II). It means there is a strong bond between height and inferior extremity length, also between height and foot length and if either of the measurement is known, the other can be calculated and this would be useful for Anthropologists and Forensic Medicine experts. And hence the regression equations were calculated for male and female.

Table III: *shows the* ***Regression equations*** *for male and female child:*

For Male:

Equation	SE of coefficient	P value
Ht = 26.5 + 1.29 ***IEL***	0.00856	0.00
Ht = 15.1 + 4.81 ***FL***	0.05870	0.00

For Female:

Equation	SE of coefficient	P value
Ht = 19.9 + 1.42 ***IFL***	0.02516	0.00
Ht = 17.1 + 4.58 ***FL***	0.07188	0.00

Discussion:

The estimation of height from various long bones, head length and hand length has been attempted by many workers. Singh and Sohal (1951)[24], Jit and Singh (1956)[25], have shown a significant correlation between height and length of clavicle. Athawale (1963)[9] derived a regression equation between total height and forearm bones. Patel, Joshi and Dongre (1964)[11], have derived regression equation between tibia and total height in Gujarati population.. Saxena et al (1981)[15], derived a regression equation between head length and height and find significant correlation coefficient, + 0.2048.

Regarding the estimation of height from inferior extremity length and foot length, Sultan et al (2005)[26] was carried out study to estimate the relationship between hand length, foot length and stature using multiple linear regression analyses. Qamra et al (1979)[27], derived regression equation between foot length and height in northwest India od adult age group. Also Patel et al (2007)[10], Chikhalkar B.G.[28], given similar regression equation from foot length.

However lower limb dimensions of pediatric age group have not frequently been used for this. The present study deals with the observations on correlation of total standing height with inferior extremity length and foot length of pediatric age group from at birth to 5yrs of age.

The average height of adult males within a population is significantly higher than that of adult females (Williams *et al.*)[3]. The results obtained in this study are in agreement with the above statement. There was distinct sexual dimorphism in the height, inferior extremity length and foot length in our study group also. The need for gender specific formulae is proved as the rate of skeletal maturity in males and females tend to vary during the course of development. The regression analysis proved to be the easiest and the reliable method (Meadows)[2].

Regression models for stature prediction were formulated using height, inferior extremity length and foot length lengths and checked for their accuracy by comparing the estimated stature and the actual stature.

As variety of factors such as, age, race, gender and nutritional status affect human development and growth and therefore, different nomograms are required for different populations (Williams *et al*.; Joshi *et al.*). The present study for the first time documents norms for height with inferior extremity length and foot length and presents gender specific linear regression models for stature prediction in pediatric population. The formulae are valid for the age group from birth upto 5 yrs of age of the subjects.

The regression models proposed will be of immense practical use in clinical practice, medicolegal, anthropological and archeological studies where the total height of a subject can be calculated if the superior extremity length or hand length is known.

Limitations:

1. In the present study, age range of only at birth to 5 years is considered.
2. Measurements of only healthy children are considered. Hence the data may not be applicable to children who are malnourished &/or suffering from congenital structural malformations.
3. The present study is a preliminary one & would be followed up by other similar studies to address the above limitations.

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Declaration for Ethical standards:

Dr Swati Ramakant Pandhare, hereby declare that during the work of present study precautions are taken for not to violate all laws of India to maintain ethical standards.

Conflict of interest:

The authors declare that they have no conflict of interest.

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