AN ANTHROPOMETRIC STUDY ON NORMAL INDIAN FEMALES

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Abstract: Body proportions are the significant phenotypic characteristics of human beings. Study of human morphology allowed research to focus on more meaningful biological, medical, social and aesthetic implications. Sixty eight normal Indian females of age ranges from 3 to 49 years of four height groups were studied for data collection. Five different body parts, viz. leg length, foot length, arm span, cephalic diameter and hand length in percentage of height was calculated to determine growth pattern i.e. allometric or isometric. The result showed that hand length and foot length changes isometrically, while, negative allometric growth is observed in arm span and cephalic diameter. Only leg length showed slight positive allometric growth.

Regression equations are formulated by using five body parts against height and all these analyses showed positive significant correlation.

The fixed ratio of arm span /height in the present study is 1.12 which is different from the unisex value 1.06. Findings of other workers and present study suggested that the ratio varies with age, ethnicity and sex.

***Index Terms*: Allometric growth, arm span/height ratio, body parts, height, isometric growth**

INTRODUCTION

Human beings display a variety of sizes, shapes, colours and other phenotypic expressions. Human body shape is an important indicator for epidemiology and environmental public health and has significant role in biological, evolutionary and demographic studies.

Age, sex and stature are the most primary characteristics for identification of an individual (Vij,2011). Estimation of height is an important parameter to establish identity of a person. Several studies have reported in predicting body height by using different body parameters (Jalzem and Gledhill, 1993; Yun et al. 1995; Mitchell and Lipschitz, 1982; Malli et al.; Bogin and Varela-Silva, 2010; Reeves et al.1996; Guerra et al. 2014). However, association of arm span and height also varied from race to race (Steele and Chemier, 1990 and Sathyavathi et al. 1979). Though several studies have been carried out in this field, very limited data is available on Indian female.

The aim of this study was to find out the correlations between different body parameters viz. arm span, hand length, leg length, foot length and cephalic circumference and standing height of females, to derive regression equations of all these parameters against height and to detect growth pattern (isometric or allometric) of these five body parts relative to height.

\ MATERIALS AND METHODS

The study was based on 68 normal Indian females of 3 to 49 years of age (height ranges from 113 to 153.6 cm).

Height was measured with the subject standing on their heels together and back as straight as possible so that heels, buttocks, shoulders and the head touched the wall. A measuring steel scale was placed against the head and wall to determine maximum height on the wall and this was marked. The height was then measured from the floor surface to the mark on the wall with flexible steel tape in centimeters.

A strict anatomical definition of leg length is the length of femur + tibia. But it is difficult to measure the actual femur length as the head of the femur is difficult to assess due to its articulation within acetabulum. A high degree of body fatness, make this bony junction difficult to access. Consequently, leg length is often defined and measured as iliac height (tip of pelvic girdle to base of heel). Leg length of a subject is assessed by measuring straight length from tip of hip bone (pelvic girdle) to the base of heel. Length of foot is measured from back of heel to the tip of toe of foot with steel scale by marking on a white paper lying on the floor surface.

Head circumference was measured by a flexible steel tape placed around head.

To determine hand length the subject was instructed to place the hand (with closed fingers) in a horizontal plain surface on a white paper. Base of palm and tip of middle finger were marked and then measured by a scale.

Data collected from the measurements of different body parts were subjected to statistical analysis to show the central tendency with standard deviation. Sets of regressions were calculated to ascertain the relationship of different body parts with height.

RESULTS

The fixed ratio of arm span/height in our population was 1.12. This value is different from the unisex 1.06 value mention by Miller et al.(2005).Regression analysis of arm span against height found to vary significantly (Fig. 1) (r^2=0.7012;P<0.0001).

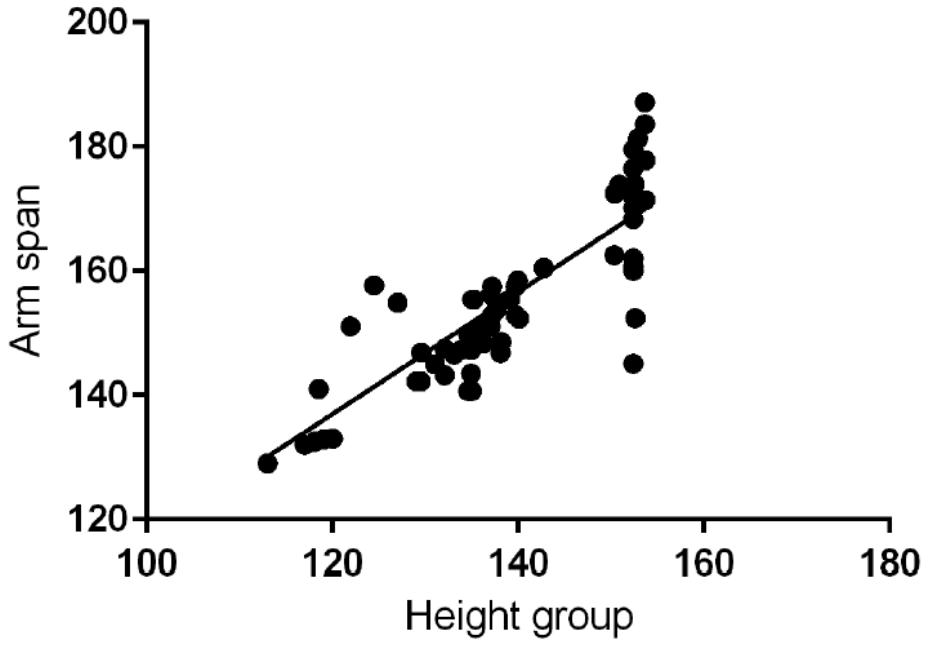

Fig.1. Regression of arm span on height of normal females (Y=0.9842X+18.89. r^2=0.7012)

A regression equation was formulated using hand length and height (Fig2) and this also shows strong significant correlation (r^2= 0.6679; P<0.0001).

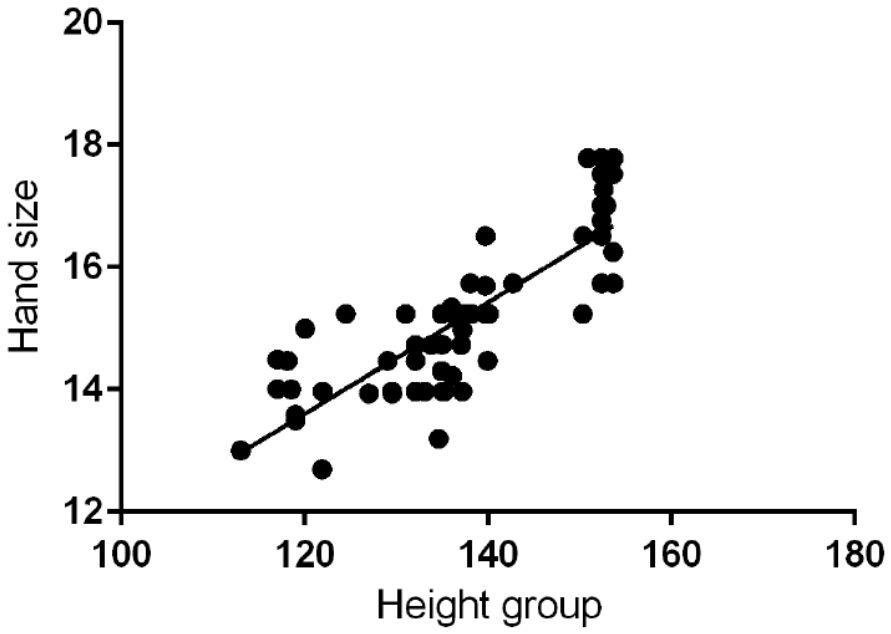

Fig.2. Regression of hand size on height of normal females (Y=0.0911X+2.67, r^2=0.6679)

Regression equation using leg length and height also yield positive significant correlation (Fig. 3, r^2=0.7617;P<0.0001).

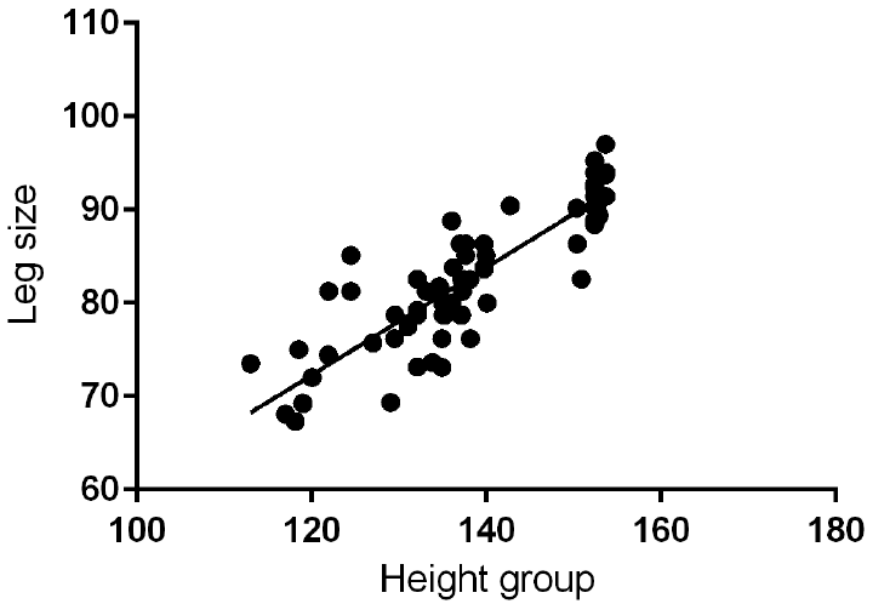

Fig.3. Regression of leg size on height of normal females (Y=0.5771X+3.04, r^2=0.7617)

Relation between foot length and height was calculated using regression analysis and it showed a highly positive significant correlation (Fig. 4, r^2=0.5760;P<0.0001).

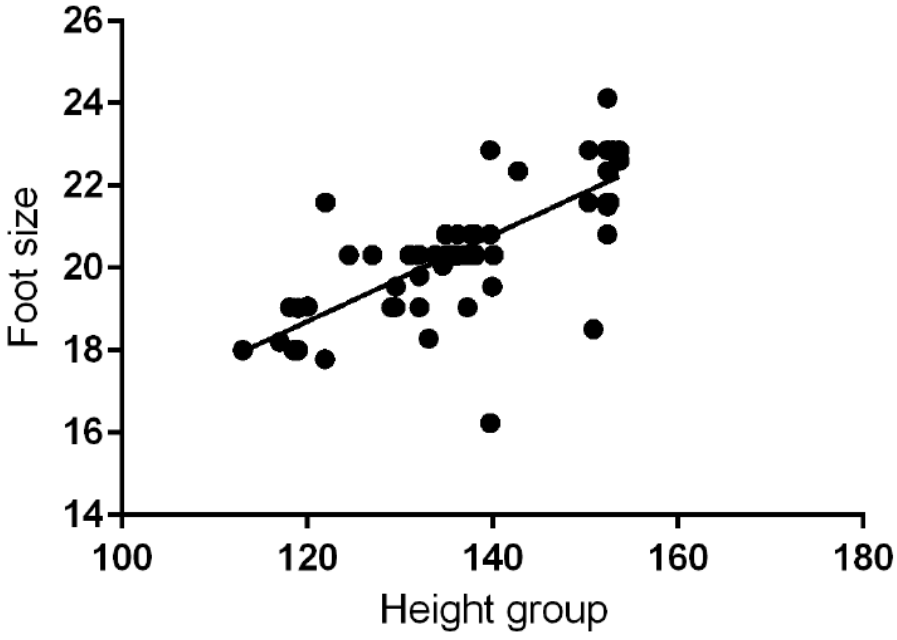

Fig.4. Regression of foot size on height of normal females (Y=0.1047X+6.13, r^2=0.5760)

Cephalic diameter and height were used to frame regression equation which showed positive significant correlation (Fig. 5, r^2= 0.7026; P<0.0262).

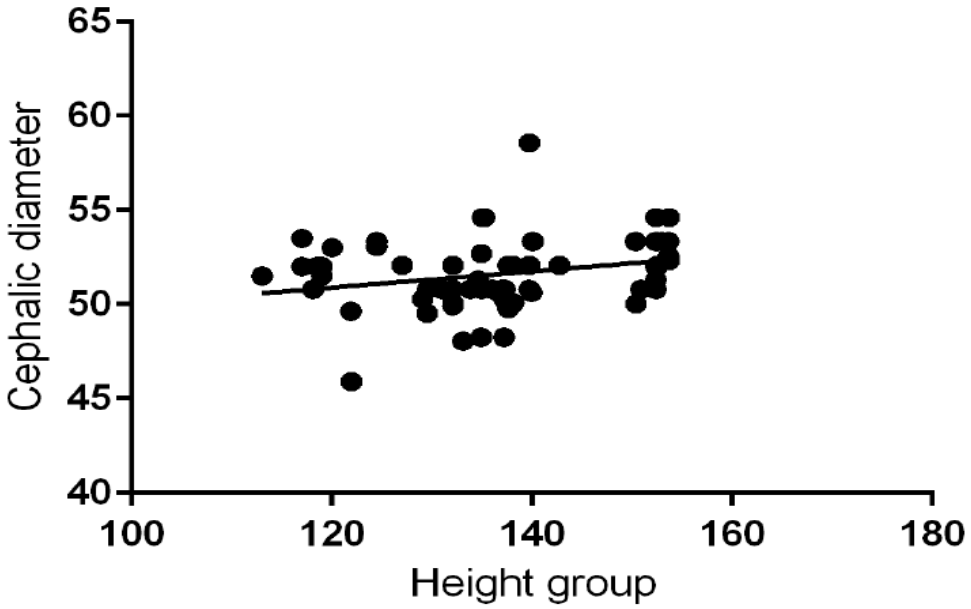

Fig.5. Regression of cephalic diameter on height of normal females (Y=0.0431X+45.72, r^2=0.7026)

Four height groups were separated to know the growth pattern of different body parts in respect to height. The height groups are : GR I-100-120cm,GR II-120-135cm,GR III -135-150cm and GR IV-150-165cm.Height groups are more appropriate than age to predict the growth of any body parts conversely ,from the size of any body part, height can be predicted quite accurately from the regression equation.

Two types of growth pattern are observed from immature to adult: Isometric growth mean that all the body parts grow at approximately the same rate and the adult proportion are not significantly different from those of the juvenile or immature and allometric growth in which reverse is true i.e. rate of growth of different body parts are not proportionate from juvenile to adult.

To estimate growth rate, length or diameter of body parts in percentage of height was calculated and presented in Table I. In respect to hand length the growth is isometric as the changes in four height group is very negligible (The differences are -0.54, -0.15 and +0.20).Foot length changes isometrically during growth as the values changes from immature to adult is also very negligible (+0.66,-0.11 and -0.20).Negative allometric growth is observed in two cases viz. arm span and cephalic diameter.Proportion of arm span relative to height is in decreasing order from juvenile to adult (The value are 14.63,3.84,and 6.74).Cephalic diameter is also reduced proportionally. The values are 4.99, 2.30 and 1.91 in four age groups. Only leg length shows slight positive allometric growth. The values are increased in first two age groups positively (The values are +2.12,+1.82 and -0.66).

Growth changes (in percentage) from minimum to maximum height group is calculated and the values in respect to hand length ,leg length, cephalic diameter, foot length and arm span are 4.24%,5.82%,2.11%,2.44% and 5.26% respectively .These values show that pronounced growth changes have occurred in leg length and arm span.

Table I. Average growth changes of five body parts (in percentage of height) of normal Indian females (n=68).

Body Parts	Height Group(in cm)			
	100-120	120-135	135-150	150-165
Hand length	11.56±0.47	11.02±0.51	10.87±0.43	11.07±0.40
Leg length	56.35±2.97	58.47±3.39	60.29±2.24	59.63±2.14
Cephalic diameter	43.64±3.19	38.65±1.95	36.35±2.39	34.44±0.84
Foot length	14.34±1.45	15.00±0.73	14.89±1.09	14.69±0.56
Arm span	99.14±3.27	84.51±2.60	80.67±2.15	73.93±2.83

DISCUSSION

Several studies have reported the effectiveness of using various body parameters in predicting body height (Jalzen and Gledhill,1993; Yun et al.1995 and Mitchell and Lipschitz 1982)

Leg length and proportion are important in the perception of human beauty ,which is often considered a sign of health and fertility ,(Bogin and Varela-Silva, 2010) . Bogin and Varela-Silva (2010) observed that between birth and puberty, the legs grow relatively faster than other post cranial body segments. For groups of children and youth, short stature is due to relatively short legs. In our study faster growth of legs are also observed which supported the findings of Bogin and Varela-Silva (2010). They also commented that across the human species as well as within geographic social and ethnic groups of people relative leg lengths reflects nutritional status and health during, the years of physical growth and also has biologically and statistically significant associations with risks for morbidity and mortality in adulthood .

Capderou et al. (2011) in his study on patients suffering from respiratory diseases, evaluated the relationship between arm span ,measured height sex and age in a Caucasian population with no chest or spine deformities. They demonstrated that age and sex have to be taken into account to best predict height from arm span .The estimation of height can be substituted to that from arm span providing sex ,age and without stature problems. In the present study relation in between arm span and height was measured only in females without considering age . The regression equation formulated here also reflects positive relationship. If correction factor for height is taken into consideration ,the equation can be useful to predict height from arm span length in non pathogenic Indian female.

Regression equation differed noticeably not only with ethnicity (Linderholm and Lindgreen 1970 and Parker et al. 1996) but also between population of the same ethnicity as shown when comparing data obtained by Parker et at.(1996) and Linderholm and Lindegreen (1970)

Capderou et al.(2011) confirmed that the regression equations, calculated separately for all 5- years age interval groups had similar slopes but statistically different intercepts and that all intercepts were significantly different from zero ($p<0.001$) . Therefore , they speculated that the age factor in arm span equations reflected the effect of age *per se* but also possibly, at least in part ,a cohort effect.

From the observations of other worker and present study , it can be calculated that in a large population the need to establish population – specific regression equation that incorporate sex and age as significant factors .

The use of a fixed ratio value of 1.06 between arm span and height has been suggested as allowing reasonable estimation of standing height from arm span . However data obtained from North American (Parker et al. 1996,Reeves et al.1996) and Indian populations (Aggarwal et al.1999) have clearly suggested that the ratio varies with age ,ethnicity and sex and that a single ratio may not be adequate for all. The fixed ratio values of arm span per height calculated for males and females were different but were within the range (1.01-1.04 for males and 1.00-1.02 for females) generally reported (Barden 1920 ,Hepper et al. 1965) , although ethnicity and population differed greatly between studies .In our study the ratio values of arm span /height is 1.12 in females.All reported ratios, including ours differed from the 1.06 value as suggested by Miller at al. (2005) . The present data also confirmed that arm span /height is not fixed. This is in consistent with the observation of Capderou et al.(2011) where they commented that the ratio is also age dependent.

Guerra et al (2014) formulated regression equation using hand length ; age and gender in estimating height .They also showed that measured height (MH) and predicted height (PH) were strongly correlated .

Malli et al (2015) showed that correlation between arm span and hand length with the standing height of both males and females was found to be an accurate predictor of the height .In our study both the parameter in relation to height ,showed good correlation which can be used to predict height with a correction factor .

Akinbami (2014) commented that cephalic index is an important anthropometric parameter in older children and adolescents of a Nigerian population. Here also cephalic diameter is highly correlated with the height of female individual.

Best prediction of height from regression equation as formulated by using different body parts is only possible when growth of any body part is isometric. Among five body parts, only hand length showed isometric growth, but other body parts showed either positive or negative allmetric growth relative to height. So it can be concluded that regression equation in between height and hand length is the best fit predicted equation atleast in normal Indian females.

The development of human body proportions is the product of environmental X genomic interactions, although few if any, specific genes are known. However research with non-pathological population indicates that the environment is a powerful force influencing body proportions than genes .

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