Estimation of stature from hand length and hand breadth in undergraduate medical students: An anthropometric study

Author info

Niraj Pandey,[1#a] Navindra Phuyal,[2*] Anusuya Shrestha,[3] Anup Pandeya,[1] Ananda Kumar Mishra,[3] Kumar Bhusal,[3]

[1]Department of Anatomy, Devdaha Medical College and Research Institute, Rupandehi, Nepal.

[2]Department of Anatomy, Rapti Academy of Health Sciences, Ghorahi, Dang, Nepal.

[3]Department of Anatomy, Maharajgunj Medical Campus, Maharjgunj, Kathmandu, Nepal.

[#a]Current Address: Department of Anatomy, Rapti Academy of Health Sciences, Ghorahi, Dang, Nepal.

***Corresponding Author:**

Email: itsmenavindra@gmail.com (NaP)

Short title: **Estimation of stature from hand length and hand breadth**

Acknowledgement

We would like to acknowledge medical students of Devdaha Medical College and Research Institute, Devdaha, Rupandehi, Nepal, who consented for participation in the study.

Abstract

Background

Stature, a factor that helps in personal identification, can be estimated using measurements of various body parts. This study measured the length and breadth of hands and the height of the participants, aiming to estimate the stature from the dimensions of the hands.

Methods

In this descriptive cross-sectional study, 195 medical students aged 18 to 24 were enrolled, and it was carried out from 3rd November 2023 to 14th April 2024. Measurement of stature was taken by stadiometer, and hand length and breadth were taken by Vernier calliper.

Results

Mean stature was higher in males (170.24±5.79 cm) as compared to females (159.01±7.261 cm). Mean length and breadth of both right and left hands were also found to be higher in males (Right hand length = 18.48±1.00 cm, Left hand length = 18.57±1.01 cm, Right hand breadth = 8.36±4.78 cm, and Left hand breadth = 8.26±5.03 cm) as compared with females (Right hand length = 16.861±0.96 cm, Left hand length = 16.897±0.95 cm, Right hand breadth = 7.31±0.58 cm, and Left hand breadth = 7.23±0.58 cm). The model summary of the multiple linear regression analysis deduced that R is .805, which indicates that there is a strong positive correlation between stature and hand dimensions with an Standard Error of Estimates of 5.083 cm and R^2 of 0.648.

Conclusion

This study was done on medical students, and it generated regression equations for estimation of stature by taking into account hand length and hand breadth. There was a positive correlation between hand dimensions and stature estimation. Similar studies can be done in the future, taking a larger population size and participants from various age groups to see if there is an influence of age factor in stature estimation.

Keywords: Body height; forensic anthropology; hand; personal identification; regression analysis

Introduction

Age, sex, stature and ethnicity are considered the "big four" for personal identification.[1] The natural height of a person who is standing upright is taken as their stature, and it is determined by a variety of factors, like hereditary and environmental.[2] A feature valuable for 'tentative identification', stature is an important parameter for medico-legal examination and deduction of the identity of the individual.[3–9] Stature can be used in verification of the identity of individuals in cases like disaster victim identification.[4] Many times forensics scientists find dismembered body parts in trenches, rubbish and elsewhere that are brought for examination, leading to challenges in identification. [4,10] Estimation of stature could be really helpful in those conditions too.

Skeletal remains and stature estimation run way back in history, and there are mainly two principles applied for that. Many statural tables have been formulated that help anthropologists and forensic experts to estimate stature.[11] Biologists, anthropologists, anatomists and forensic pathologists have been focusing on the relationship of different body parts for years. Stature estimation has been done using various measurements of body segments and body proportions. Long bones are the most common among all.[7] A comparison of the relationships between body segments is used by anthropologists to indicate variations among the origins of various ethnic groups. It is also valuable in finding the association between various lifestyles, usage of energy and locomotor patterns.[12] Stature estimation using handprints can be a valuable asset in solving crimes too.[12] Although there are established relationships between body parameters, they tend to vary between populations of different regions or different ethnicities that are affected by the level of physical activity and the status of nutrition.[12,13]

Studies have been done using other body parameters like foot length, and very few studies have been done using both the length and breadth of the hand in this region.

This study measured the length and breadth of hands and stature of the individuals. It aimed to estimate the stature from dimensions of the hands and see if there is any correlation between them. Being done on the undergraduate medical students, we have also considered sex and age indicators of the individuals.

Methods

A cross-sectional, observational study was carried out. It was done on medical students of Devdaha Medical College and Research Institute from 3rd November 2023 to 14th April 2024, after ethical approval was taken from the Institutional Review Committee of Devdaha Medical College and Research Institute, Devdaha, Rupandehi, Nepal, with approval number: 24/2023 (Ref No: 45610801081).

The sample size was calculated using the formula:

$$N = [(Z\alpha + Z\beta) / C]^2 + 3$$

Where:

- $Z\alpha=1.96$ (95% confidence interval)
- $Z\beta=0.84$ (80% power)
- $C=0.5 \ln\{(1+r)/(1-r)\}$
- $r = 0.34$ (Coefficient correlation) [3]

The minimum sample size for each gender was found to be 66. In our study, we included 195 students (80 female and 115 male). Participants were explained about the objectives of the study and the procedure of data collection and also about privacy and confidentiality. They were also informed about their right to refuse and withdraw consent at any time. The measurements were taken only after voluntary written informed consents were obtained.

Participants with deformities of the hand and vertebra, with a history of trauma to the hand and with features of dysmorphic syndromes were excluded. All other students who consented were included in the study.

Stature was measured using a stadiometer to the nearest centimetre (cm). Study participants were asked to stand erect in anatomical position, barefoot. Head was oriented in Frankfurt's plane, and the measurement was taken from the vertex of head to the sole of the foot.

Participants were asked to rest their hand against a flat cardboard in supine position with fully extended fingers. The thumb was kept in extension while all other fingers were adducted. The length of the hand was taken from the inter-stylion point, i.e., mid-point of the line joining the most distal point of the radial styloid process (stylion radiale) and the most distal point of the ulnar styloid process (stylion ulnare), to the most distal tip of the third finger. Breadth of the hand was taken from the most medially projected end present on the head of the second metacarpal with the hand stretched, i.e., metacarpal-radiale to the most projected point laterally on the head of the fifth metacarpal with the hands stretched, i.e., metacarpal-ulnare, as shown in Fig 1. Measurements were taken using a Vernier calliper in millimetres(mm) and converted to the nearest centimetre (cm). All the measurements were taken three times, and an average was calculated and noted in the pro forma. Data entry was done in a Microsoft Excel spreadsheet and later transferred to SPSS. Data analysis was done using SPSS version 16.

Fig 1: Measurements of hand.

A = stylion ulnare, B = stylion radiale, C = Inter-stylion, D = tip of third finger, E = metacarpal radiale, F = metacarpal ulnare, DC = Length of hand, EF = Breadth of hand.

Results

In this study 195 undergraduate medical students were enrolled; among them, 80 (41%) were female and 115 (59%) were male, with ages ranging from 18 to 24 years, with a mean age of 20.2 ± 1.35 years.

Table 1. Shows descriptive statistics of stature according to sex.

Table 2. Illustrates descriptive statistics of hand length according to sex.

Table 3. Illustrates descriptive statistics of hand breadth according to sex.

Table 1: Distribution of stature according to sex

Stature(cm)	**Female (n = 80)**	**Male (n = 115)**
Mean	159.01	170.24
Std. Deviation	7.261	5.794
Std. Error of Mean	0.812	0.540
Minimum	142	155
Maximum	188	188

Table 2: Distribution of hand length according to sex

Hand length (cm)	**Female**		**Male**	
	Right side	**Left side**	**Right side**	**Left side**
Minimum	14.8	15.0	16.0	16.0
Maximum	19.4	19.5	21.5	21.5
Mean	16.861	16.897	18.482	18.570

Std. Deviation	.9659	.9487	1.0082	1.015

Table 3: Distribution of hand breadth according to sex

Hand Breadth (cm)	Female		Male	
	Right side	**Left side**	**Right side**	**Left side**
Minimum	6.2	6.0	7.5	6.7
Maximum	9.1	9.2	9.9	9.7
Mean	7.311	7.229	8.356	8.264
Std. Deviation	.5846	.5818	.4780	.5034

For the estimation of stature from the length/breadth of the hand linear regression formula would be

Height (y) = a + b × Hand length/breadth (x)

[a = Constant and b = Independent variable]

Table 4: Linear regression equation for estimation of height from hand length and hand breadth in male and female

Male	Female
Height = 100.029 + (3.799 × RHL[a]) [R = .661, R^2 = .437, SEE = 4.4, $p < 0.001$]	Height = 74.114 + (5.035 × RHL[a]) [R = .670, R^2 = .449, SEE = 5.4, $p < 0.001$]
Height = 99.892 + (3.788 × LHL[b]) [R = .664, R^2 = .441, SEE = 4.4, $p < 0.001$]	Height = 73.668 + (5.051 × LHL[b]) [R = .660, R^2 = .435, SEE = 5.4, $p < 0.001$]

Height = 130.672 + (4.736 × RHB[c]) [R = .391 R^2 = .153, SEE = 5.4, p < 0.001]	Height = 145.720 + (1.818 × RHB[c]) [R = .146, R^2 = .021, SEE = 7.2, p = 0.195]
Height = 133.334 + (4.466 × LHB[d]) [R = .388, R^2 = .151, SEE = 5.4, p < 0.001]	Height = 139.505 + (2.699 × LHB[d]) [R = .216, R^2 = .047, SEE = 7.1, p = 0.054]

[a]RHL = Right hand length, [b]LHL = Left hand length, [c]RHB = Right hand breadth, [d]LHB = Left hand breadth.

Regression equation for estimation of stature with hand length and hand breadth combined:

In female: Height = 77.633 – (6.307 × RHB) + (4.857 × LHB) + (3.591 × RHL) + (1.884 × LHL)

In Male: Height = 94.462 + (1.254 × RHL) + (2.313 × LHL) + (1.065 × RHB) + (0.092 × LHB)

Table 5 explains the regression equation and its analysis. It indicates that R is .702 for females; that means there is a moderate to strong correlation between hand dimensions and stature. There is a 49.2% variance in female height, while the predictions deviate by 5.3cm on average. The R value for males is .671, which means there is moderate correlation between hand dimensions and stature. The model also explains that there is 45.1% variance in male height, and predictions are about 4.4 cm off on average.

Table 5: Model summary obtained after regression analysis

Gender	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Female	**1**	.702	.492	.465	5.310
Male	**1**	.671	.451	.431	4.372

Multiple linear regression equation is as follows:

Height (cm) = 69.652 – (1.084 × RHB) + (2.307 × LHB) + (2.394 × RHL) + (2.451 × LHL)

[R = .807, R^2 = .652, SEE = 5.056]

Table 6: Descriptive statistics of actual height and estimated height

n = 195	**Height(cm)**	**Estimated Height(cm)**
Minimum	142	151
Maximum	188	185
Mean	165.64	165.43
Std. Deviation	8.478	6.856

The Kolmogorov-Smirnov test was done, which deduced that data was seen to be distributed normally ($p < 0.001$) for actual height and not normally ($p = 0.76$), so Spearman's rho correlation was done. **Table 7** displays the results. The correlation coefficient was 0.810, which showed a strong positive correlation, and the values were statistically significant ($p < 0.001$).

Table 7: Spearman's rho correlation between actual height and estimated height

		Height (cm)	**Estimated Stature (cm)**
Height (cm)	Correlation Coefficient	1.000	.810
	Sig. (2-tailed)	.	.000
Estimated Stature (cm)	Correlation Coefficient	.810	1.000
	Sig. (2-tailed)	.000	.

Fig 2 : Scatter plot showing relationship between stature and hand lengths in male and female.. Is presented here to show the liner relationship between stature and hand lengths.

Fig 3. Is presented here to show the linear relationship between stature and hand breadths.

Fig 2 : Scatter plot showing relationship between stature and hand lengths in male and female.

(A) Between stature and RHL in females. (B) Between stature and RHL in males. (C) Between stature and LHL in females. (D) Between stature and LHL in males.

Fig 3: Scatter plot showing relation between stature and hand breadths in male and female.

(A) Between stature and RHB in females. (B) Between stature and RHB in males. (C) Between stature and LHB in females. (D) Between stature and LHB in males.

Discussion

Stature is a changing value, and it depends upon various factors. In this study we tried to find if estimation of stature can be done by taking only the measurements of the length and breadth of the hand. Mean length and breadth of both right and left hands were found to be higher in males (RHL = 18.48±1.00 cm, LHL = 18.57±1.01 cm, RHB = 8.36±4.78 cm and LHB = 8.26±5.03 cm) as compared with females (RHL = 16.861±0.96 cm, LHL = 16.897±0.95 cm, RHB = 7.31±0.58 cm, and LHB = 7.23±0.58 cm). Mean stature was also higher in males (170.24±5.79 cm) as compared to females (159.01±7.261 cm). It is similar to many other studies. [3–6,14–19] In a study done by Shakya et al., upper arm length of the participants was taken for stature estimation instead of hand length, and it was also seen to be higher in males (Right = 41.4667±2.993 cm, Left = 40.598±2.849 cm) compared to female (Right =

37.436±1.807 cm, Left = 36.920±1.735 cm).[17] Male being genetically taller than female is the reason for this discrepancy.

Among the single-variable linear equations where stature was taken as the dependent variable, RHL and LHL both displayed the lowest SEE (4.4 cm) in males, whereas RHB and LHB had the same SEE as well (5.4 cm), and all were statistically significant ($p<0.001$). Thus, hand lengths can be considered a more accurate predictor of stature in males. Similarly, in females, RHL and LHL had the same lowest SEE and were statistically significant ($p<0.001$), whereas RHB had the highest SEE and was not statistically significant ($p = 0.195$). Thus, it can be deduced that RHL and LHL can be strong, accurate predictors of height in the female population. SEE was lower when all the variables were applied as explanatory variables in the case of males (4.37 cm) and females (5.3 cm). SEE in this study ranged from 4.4 to 7.2 cm; however, a study done by Ozaslan in the Turkish population, SEE ranged from 6.03 to 6.39 cm [20] and much lower, 3.49 to 4.28 cm, in a study done by Pal et al.[7] In another study done by Habib and Kamal, in the Egyptian population, using hand length and phalanges for stature estimation, SEE ranged from 5.3 to 7.27 cm, and the values are much similar to our study.[21] Rastogi et al. did a study in the Indian population and derived SEE ranging from 4.11 to 5.99 cm, which was also lower than the present study.[22] Sanli et al. did a study in the Turkish population using hand length as a variable for stature estimation and reported an SEE of 3.49 cm.[12] Panjokh et al. reported SEE of 4.87 in males and 5.11 cm in females in a multiple regression equation where the variables were forearm length, hand length and hand width.[18] In a study done by Shrestha et al., hand breadth showed a weak positive correlation, and hand length showed a moderate to strong positive correlation with stature.[15]

The model summary of the multiple linear regression analysis deduced that R is .807, which indicates that there is a strong positive correlation between stature and hand dimensions. SEE is 5.056, indicating that the prediction deviates from the actual height by 5cm on average. R^2

is 0.652, and adjusted R^2 is 0.644, depicting the robustness of the regression with $p < 0.001$ confirming that it is statistically significant. The linear regression model was found to be valid in other similar studies.[4,14] Pandeya et al. took only hand length as a parameter for their estimation of the stature;[14] likewise, in our study we have also included hand breadth as a parameter, making regression analysis more extensive. The R and R^2 and the SEE values of the multiple linear regression equation were almost similar to the values obtained from equations of single variables, except for right hand breadth and left hand breadth in females, where R and R^2 were very low and SEE was higher compared to equations obtained from other single variables. Pal et al. deduced that a multiple linear regression equation where explanatory variables were hand length, palm length, hand breadth and maximum hand breadth, whereas stature was the dependent variable, had higher reliability with lower SEE and high R and R^2 values when compared to the equations obtained from single variables.[7] Palm length and maximum hand breadth were two extra variables included in Pal's study compared to our study that may have caused this difference in the multiple and single variable linear regression equations.

Spearman's rho correlation coefficient between height and estimated height was 0.810 ($p < 0.001$), this showed that as height increases estimated height also increases. Thus, the estimated height obtained from the multiple regression equation can be a proxy for the actual height.

This study was done on a limited number of students at a medical college, so in order to decrease bias and add more significance larger population sample can be taken in the future. It included individuals of age groups 18 – 24 and cannot represent the entire population of various age groups. So, in future, similar studies can be done using participants from various age groups so that age factors can also be analysed in the estimation of stature. We used hand length and breadth as our variables, while some studies show that SEE can be decreased using more

variables like foot length and forearm and arm length, etc. This study paves a way for such studies to be done in future.

Conclusions

Stature is an important entity for personal identification of the individual. Estimation of stature can be done from various body parts, and many studies have been done to find their significance. This study was done on medical students, and it generated regression equations for estimation of stature by taking into account hand length and hand breadth. Mean length and breadth of hand and stature were seen to be more in males than in females. The multiple linear regression equation showed that there is a strong positive correlation between stature and the hand dimensions. Similar studies can be done in the future taking a larger population size and participants from various age groups to see if there is an influence of age factor in stature estimation.

Abbreviations

RHL = Right Hand Length

LHL = Left Hand Length

RHB = Right Hand Breadth

LHB = Left Hand Breadth

SEE = Standard Error of Estimate

Acknowledgements

We would like to acknowledge medical students of Devdaha Medical College and Research Institute, Devdaha, Rupandehi, Nepal, who consented for participation in the study.

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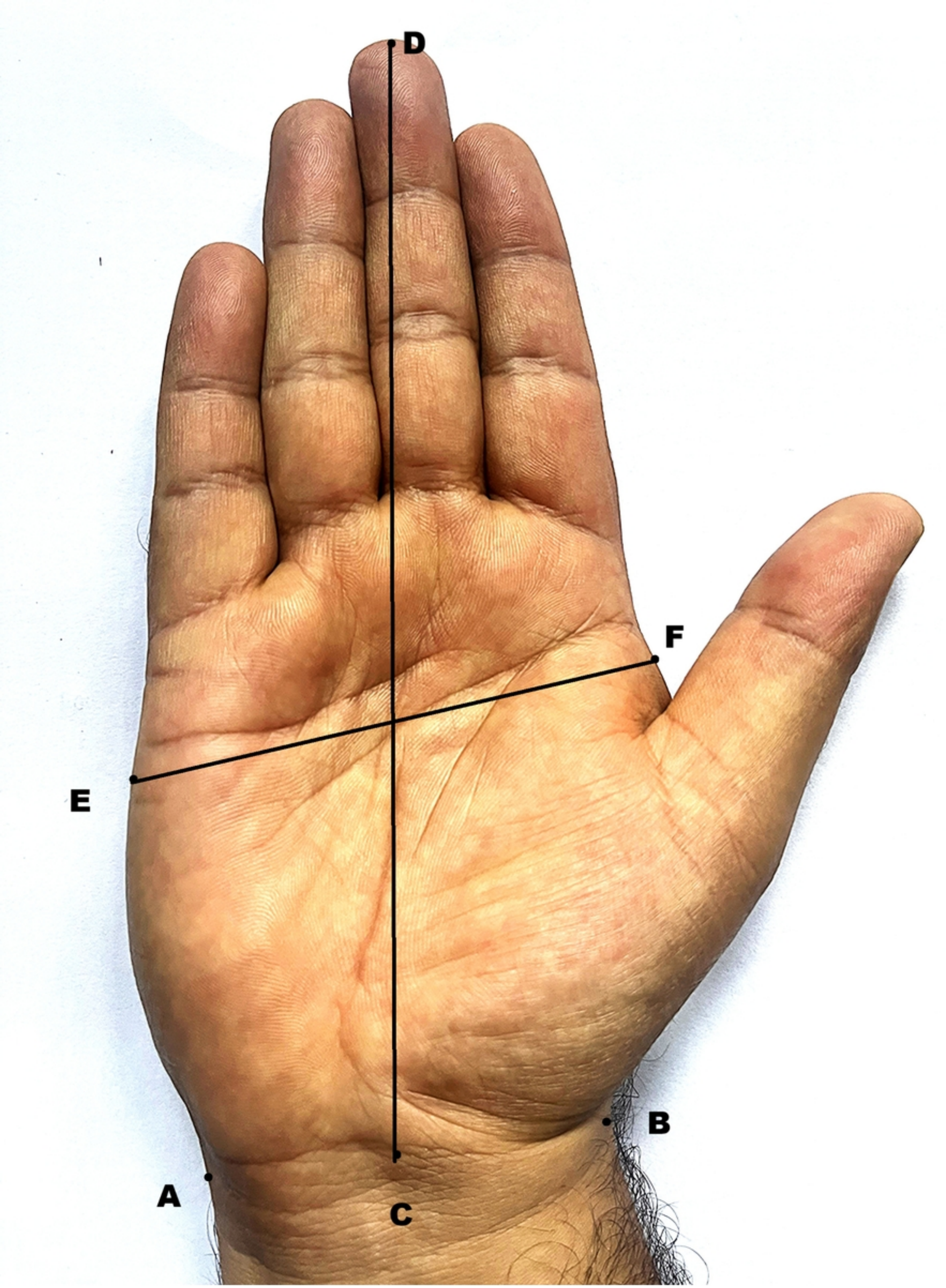

Fig1.

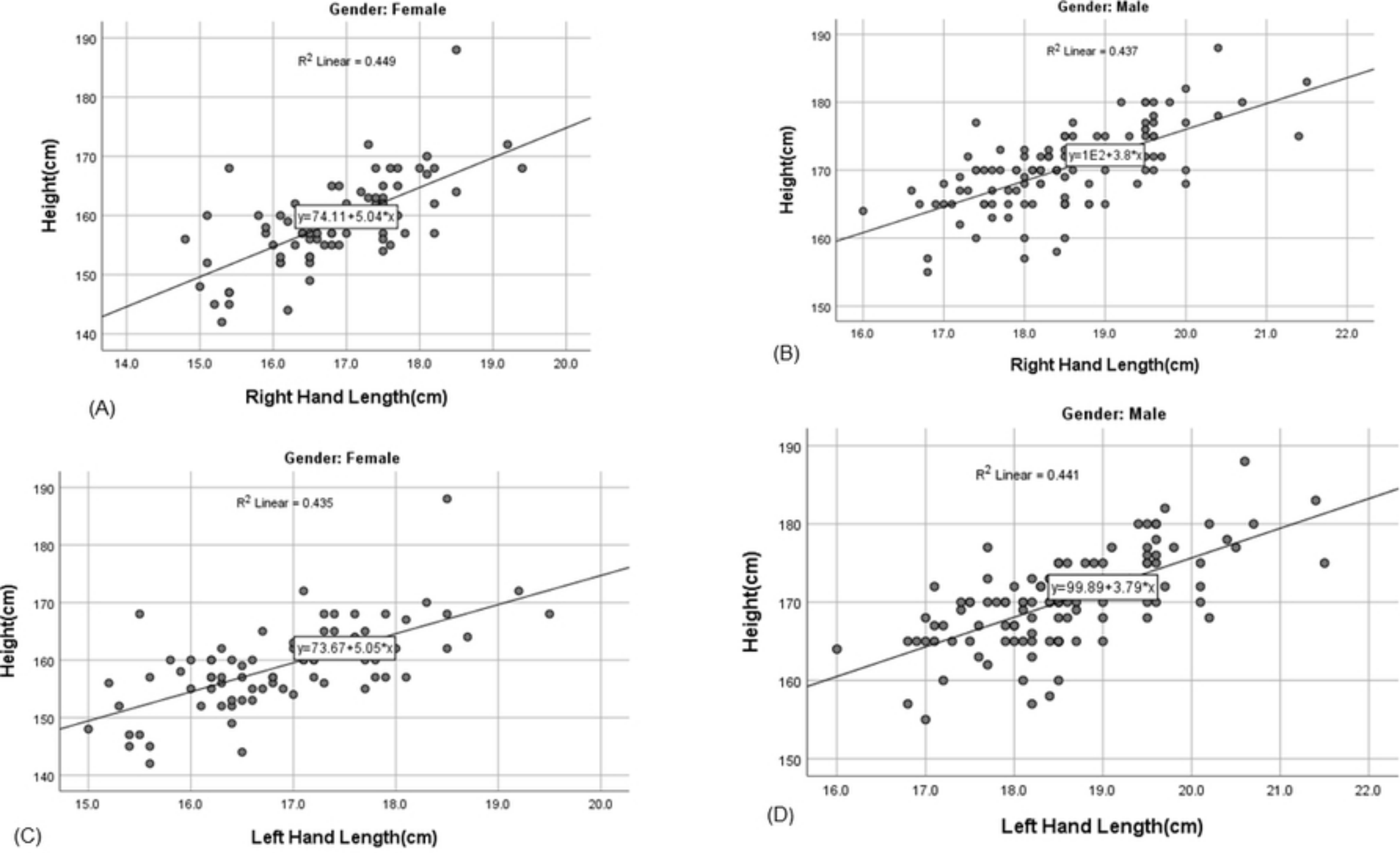
Gender: Female
R² Linear = 0.449
y=74.11+5.04*x
Height(cm)
Right Hand Length(cm)
(A)
Gender: Male
R² Linear = 0.437
y=1E2+3.8*x
Height(cm)
Right Hand Length(cm)
(B)
Gender: Female
R² Linear = 0.435
y=73.67+5.05*x
Height(cm)
Left Hand Length(cm)
(C)
Gender: Male
R² Linear = 0.441
y=99.89+3.79*x
Height(cm)
Left Hand Length(cm)
(D)

Fig 2.

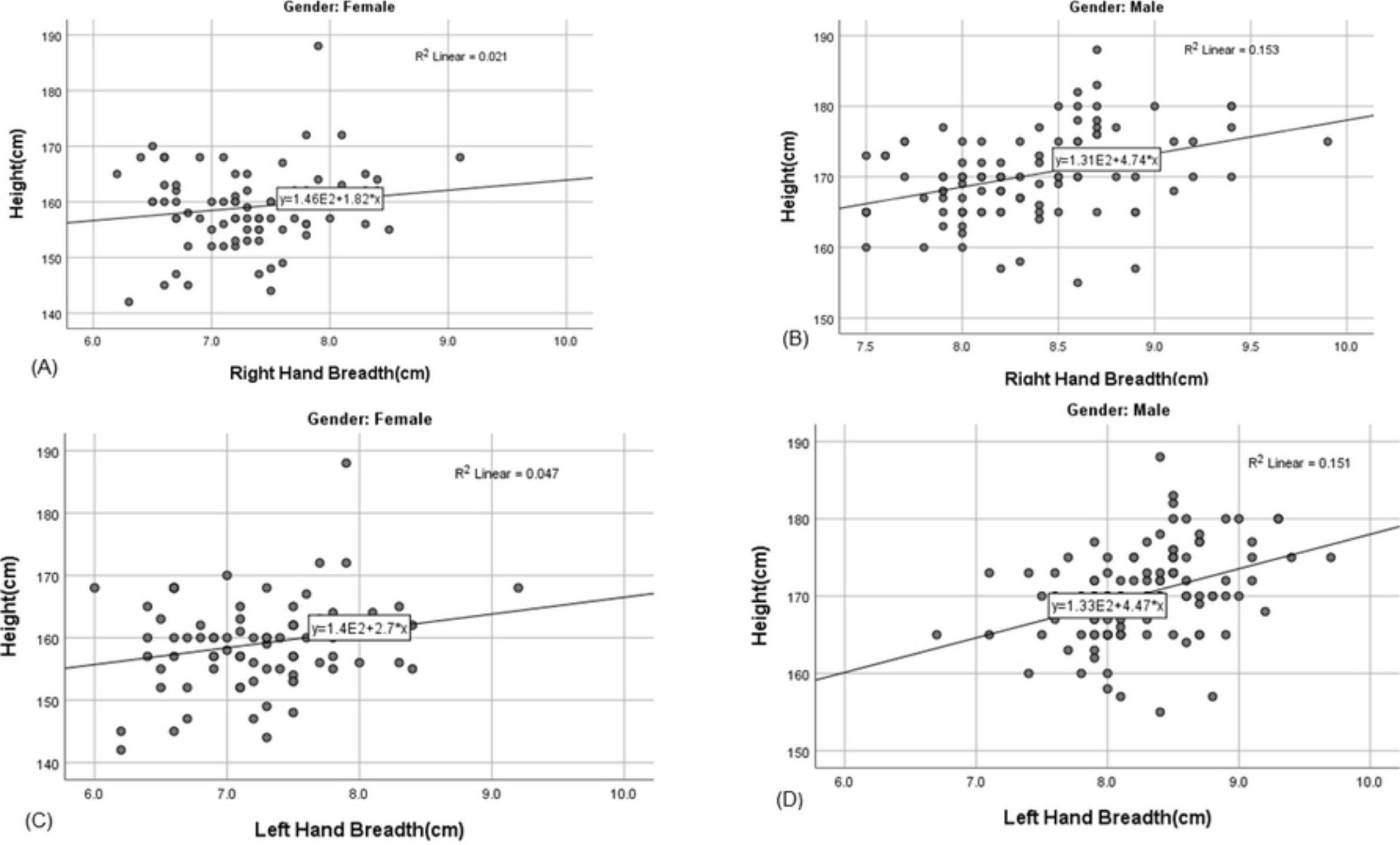
Gender: Female
R² Linear = 0.021
y=1.46E2+1.82*x
Height(cm)
Right Hand Breadth(cm)
(A)
Gender: Male
R² Linear = 0.153
y=1.31E2+4.74*x
Height(cm)
Right Hand Breadth(cm)
(B)
Gender: Female
R² Linear = 0.047
y=1.4E2+2.7*x
Height(cm)
Left Hand Breadth(cm)
(C)
Gender: Male
R² Linear = 0.151
y=1.33E2+4.47*x
Height(cm)
Left Hand Breadth(cm)
(D)

Fig 3.