Original Article

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Correlation of Hand Dimensions with Foot Dimensions: A Central Indian Study

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Abstract

Background and Objectives: Forensic investigation necessitates estimation of age, sex, stature and weight of human individual. Researchers all over the world studied various human parts in different ways. Both halves of human body are fairly symmetrical. It is assumed that each body part is having some relation with other part. Present study was conducted with the aim to study the relationship between hand and foot dimensions. *Methodology:* This cross-sectional study was conducted amongst 1000 participants (500 male and 500 female) of ESIC Institute Gulbarga over a period of 14 months. Hand and foot dimensions were measured. *Results:* Significant correlation was observed between hand and foot dimensions in both sexes and on both sides. Correlation co-efficient 'r' and Linear regression equation was calculated. *Interpretation and Conclusion:* Statistically significant correlation was observed between hand and foot dimensions of both side sin both sexes. This data would be useful for forensic investigations and anthropometric studies.

Keywords: Correlation; Hand Length; Hand Breadth; Foot Length; Foot Breadth; Linear Regression Coefficient; Crime.

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Introduction

Forensic investigation necessitates estimation of age, sex, stature and weight of human individual. Researchers all over the world have studied various human parts in different ways. It is assumed that each body part is having some relation with other part. Relationships of hand length and foot length with various body part measurements have been studied by authors like Anitha Oommen *et al.*[1] (2005), Prakash M Mohite *at al.*[2] (2015), Chikhalkar BG *et al.*[3] (2008) in Indian population. Crime has increased in Central part of India over the last two decades. Hand and foot impressions are one of the commonest evidence left at crime site from which stature, age, sex, weight of the suspect has to be correlated. Previous studies conducted on similar topicin our region have not yielded significant results. Hence, statistically significant database regarding correlation of hand and foot dimensions are not available for the population of this region. Hence this study was proposed over a large sample size with multiple variables being studied with an aim to develop a reliable database useful for forensic investigation, anthropometric studies.

Aim

To study the relationship of hand dimensions with foot dimensions.

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Materials and Methods

***Study design*:** Descriptive cross sectional study.

***Setting*:** Anthropometric section of Department of Anatomy, ESIC Institute Gulbarga, Karnataka.

***Duration of study*:** 14 months; From 31st October, 2017–31st December 2018.

***Sample size*:** 1000 which includes Medical, Dental and Nursing students aged between 17 and 20 years of age in ESIC Institute Gulbarga.

Sampling technique: *Inclusion criteria*: Medical, Dental and Nursing students aged between 17 and 20 years in ESIC Institute Gulbarga.

Exclusion criteria: Students of NRI quota and students those with poorly defined wrist creases, deformities of vertebral column and limbs, contractures, missing limbs, history of trauma to hand and foot, with features suggestive of dysmorphic syndromes, chronic illness, hormonal therapy were excluded from the study.

***Sample selection*:**

Simple random sampling method[4] as 1000 participants were selected out of total 3000 Medical, Dental and Nursing students of ESIC Institute Gulbarga satisfying the inclusion criteria. Participants belonged to 1st to 3rd year as they were easily accessible and represented the young adult age group.

Data collection procedure

Hand Length: Each subject was made to place his/her hand on a white paper with the palm facing upwards keeping the fingers close together with the thumb lying comfortably but not tightly against the radial aspect of the hand and index finger (**Fig. 1**). A tracing of the hand was made with a lead pencil. The tracing proceeded from the radial styloid process to the ulnar styloid process. A line designated as the inter-styloid line was drawn joining the two styloid tips. Hand length (L) was measured using a Vernier Slide Calipers as the distance between the distal crease of wrist to tip of middle finger.[2]

Fig 1: Measurement of hand length

Hand Breadth: Measured from 1st metacarpo-phalangeal joint to base of 5th metacarpal in *cm* using Vernier Caliper[2] (**Fig 2**).

Fig 2: Measurement of hand breadth

Foot Length: Each subject will stand on a Calibrated Foot Board with his/her back against the wall in such a manner that the posterior most point of the heel will gently touch the wall. A vertical stop was placed against the anterior most point of the foot. The distance between the posterior most point of the heel and the anterior most point of the foot was measured as the foot length (Anitha Oommen *et al.*,[1] 2005) (**Fig. 3**).

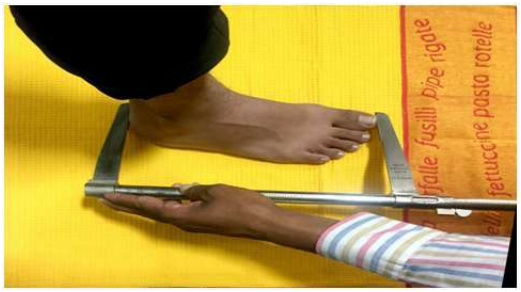


Fig 3: Measurement of foot length

Foot Breadth: It will be measured as distance between Metatarsal tibiale (point projecting most medially on the head of the 1st metatarsal bone) and Metatarsal Fibulare (point projecting most laterally on the head of the 5th metatarsal bone) (Rati Tandon *et al.*,[5] 2016) (**Fig. 4**).

Fig 4: Measurement of foot breadth

Data collection tools: Vernier slide calipers, calibrated foot board, stadiometer, regular weight machine, questionnaire for collection of personal details, academic scores, lead pencils, stationary etc. Data collected was tabulated, statistically analyzed and graphically represented.

Results and Discussion

Foot length on right side in male ranged from 22.6 *cm*–28.9 *cm* with **mean of 25.18 *cm*** and SD of 1.32. Foot length on left side in male ranged from 22.8 *cm* –29.0 *cm* with **mean of 25.31 *cm*** and SD of 1.15, **Table 1**.

These findings correspond with studies of Anitha Oommenet *et al.*[1], Rati Tandon *et al.*[5], Patel SM, Shah GV *et al.*[7] 2007, Prakash M Mohite *et al.*[2] (2015). Shown in **Table 9**.

Foot length on right side in female ranged from 21.0 *cm* –25.7 *cm* with **mean of 23.39 *cm*** and SD of 1.19. Foot length on left side in female ranged from 21.5 *cm*–25.4 *cm* with **mean of 23.19 *cm*** and SD of 0.97, **Table 2**.

These findings correspond with studies of Anitha Oommenet *et al.*[1], Rati Tandon *et al.*[5], Patel SM, Shah GV *et al.*[9] 2007, Prakash M Mohite *et al.*[2] (2015). Shown in **Table 9**.

Table 1: Correlation of Hand length and Foot length in male (right**).**

Variables	Minimum	Maximum	Range	Mean	SD	N	Correlation-*r*	*p*-value
Hand length right	16.5	23.8	7.3	18.9	1.16	500	$r = 0.536$	$p < 0.01$ HS
Foot length right	22.6	28.9	6.3	25.18	1.32	500		
Linear Regression Equation	Hand length right in males = 8.602 + 0.409 (Foot length right)							

Table 2: Correlation of Hand length and Foot length in male (left).

Variables	Minimum	Maximum	Range	Mean	SD	N	Correlation-*r*	*p*-value
Hand length left	16.5	24.6	8.1	18.96	1.27	500	$r = 0.446$	$p < 0.01$ HS
Foot length left	22.8	29.0	6.2	25.31	1.16	500		
Linear Regression Equation	Hand length left in males = 6.558 + 0.49 (Foot length left)							

Foot breadth on right side in male ranged from 7.8 *cm*–10.9 *cm* with **mean of 9.39 *cm*** and SD of 0.70. Foot breadth on left side ranged from 7.8 *cm* – 11.5 *cm* with **mean of 9.35 *cm*** and SD of 0.59, **Table 3**.

These findings correspond with studies of B Danborno, A Elukpoet *et al.*[6] (2007), Rati Tandon *et al.*,[7] Patel PN, Tanna JA *et al.*[8] (2012), Chikhalkar BG *et al.*[3] (2008). Shown in **Table 9**.

Foot breadth on right side in female ranged from 7.5 *cm*–9.8 *cm* with **mean of 8.45 *cm*** and SD of 0.52. Foot breadth on left side ranged from 7.7 *cm*–9.8 *cm* with **mean of 8.53 *cm*** and SD of 0.48, **Table 4**.

These findings correspond with studies of B Danborno, A Elukpoet *et al.*[6] (2007), Rati Tandon *et al.*[5], Patel PN, Tanna JA *et al.*[8] (2012), Chikhalkar BG *et al.*[3] (2008). Shown in **Table 9**.

Hand length on right side ranged from 13.9 *cm*–23.8 *cm* with **mean of 18.11 *cm*** and SD of 1.38. Hand length on left side ranged from 13.9 *cm*–24.6 *cm* with **mean of 18.10 *cm*** and SD of 1.47. These findings correspond closely with those of Oommenet *et al.*[1], Chikhalkar *et al.*[3] and Kavyashree *et al.*[10], (**Table 9**).

Hand Breadth on Right side ranged from 7.6 *cm*–19.0 *cm* with **mean of 9.91 *cm*** and SD of 0.76. Hand Breadth on left side ranged from 7.6 *cm*–19.0 *cm* with **mean of 9.83 *cm*** and SD of 0.77, (**Table 9**). These findings were higher than those observed in almost all the previous studies (**Table 4**). This is might because in present study, hand breadth was measured from 1st metacarpo-phalangeal joint to

Table 3: Correlation of Hand length and Foot length in female (right).

Variables	Minimum	Maximum	Range	Mean	SD	N	Correlation-*r*	*p*-value
Hand length right	13.9	19.7	5.8	17.18	0.99	500	$r = 0.132$	$P < 0.05$ S
Foot length right	21.0	25.7	4.7	23.39	1.19	500		
Linear Regression Equation	Hand length right in females = 15.15 + 0.051 (Foot length right)							

Table 4: Correlation of Hand length and Foot length in female (left).

Variables	Minimum	Maximum	Range	Mean	SD	N	Correlation-*r*	*p*-value
Hand length left	13.9	19.7	5.8	17.11	0.99	500	$r = 0.138$	$p < 0.05$ S
Foot length left	21.5	25.4	3.9	23.19	0.96	500		
Linear Regression Equation	Hand length left in females = 14.21 + 0.063 (Foot length left)							

base of 5th metacarpal; whereas in previous studies it was measured from 2nd metacarpo-phalangeal joint to base of 5th metacarpal. Hand breadth observations matched with Prakash M. Mohite *et al*.[2]

Linear regression co-efficient has been calculated for different combinations of body parts. Observations have been shown in (**Tables 1–8** also **Graphs 1–8).**

Table 5: Correlation of Hand breadth and Foot breadth in male (right).

Variables	Minimum	Maximum	Range	Mean	SD	N	Correlation-*r*	*p*-value
Hand breadth right	8.8	19.0	10.2	10.36	0.68	500	$r = 0.240$	$p < 0.01$ S
Foot breadth right	7.8	10.9	3.1	9.39	0.71	500		
Linear Regression Equation	Hand breadth right in males = 8.175 + 0.22 (Foot breadth right)							

Table 6: Correlation of Hand breadth and Foot breadth in male (left).

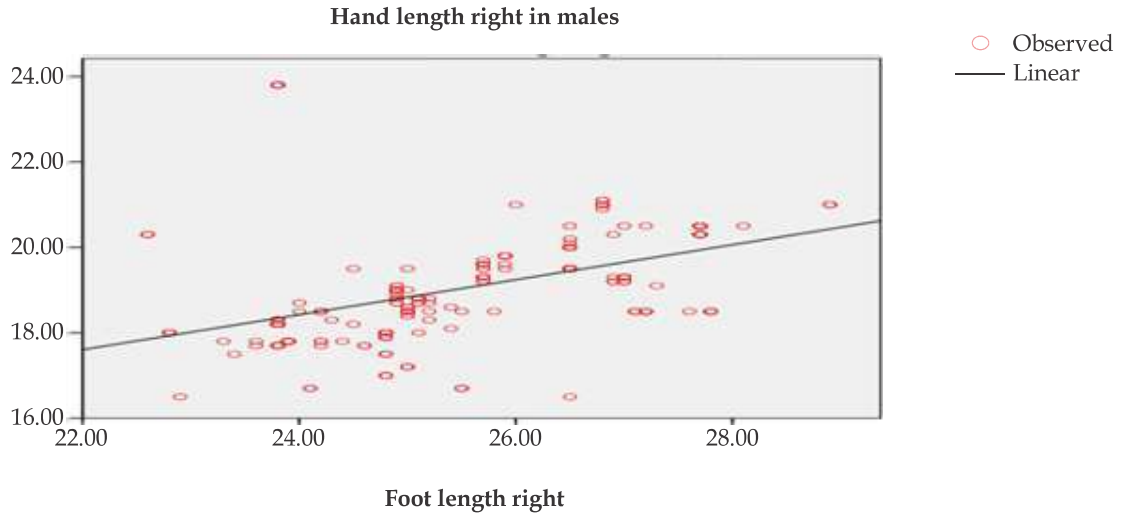
Variables	Minimum	Maximum	Range	Mean	SD	N	Correlation-*r*	*p*-value
Hand breadth left	8.9	19	10.1	10.29	0.69	500	$r = 0.206$	$p < 0.01$ HS
Foot breadth left	7.8	11.5	3.7	9.35	0.59	500		
Linear Regression Equation	Hand breadth left in males = 8.252 + 0.219 (Foot breadth left)							

Table 7: Correlation of Hand breadth and Foot breadth in female (right).

Variables	Minimum	Maximum	Range	Mean	SD	N	Correlation-*r*	*p*-value
Hand breadth right	7.6	10.6	2.3	9.39	0.47	500	$r = 0.182$	$p < 0.01$ HS
Foot breadth right	7.5	9.8	2.3	8.45	0.52	500		
Linear Regression Equation	Hand breadth right in females = 8.09 + 0.154 (Foot breadth right)							

Table 8: Correlation of Hand breadth and Foot breadth in female (left).

Variables	Minimum	Maximum	Range	Mean	SD	N	Correlation-*r*	*p*-value
Hand breadth left	7.6	10.6	2.4	9.31	0.47	500	$r = 0.164$	$p < 0.01$ HS
Foot breadth left	7.7	9.8	2.1	8.52	0.47	500		
Linear Regression Equation	Hand breadth left in females = 8.023 + 0.152 (Foot breadth left)							

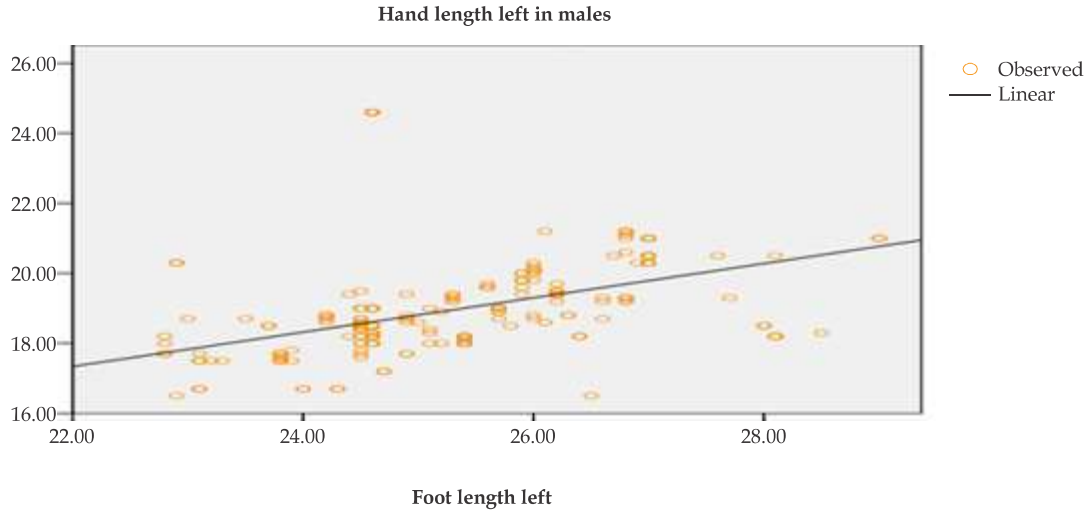


Graph 1: ROC curve of hand length v/s Foot length of right in males

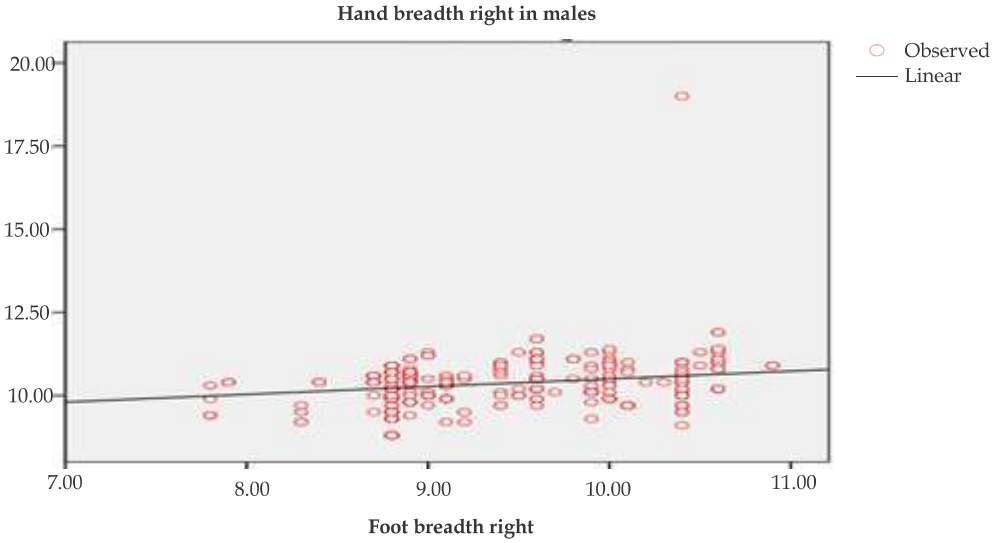
Table 9: Comparison of present study with previous studies.

Sl. no.	Study/Author/ Year	Variable studied	Sample size	Observations							
				Mean hand length		Mean hand breadth		Mean foot length		Mean foot breadth	
				Right M/F	Left M/F	Right M/F	Left M/F	Right M/F	Left M/F	Right M/F	Left M/F
1	Anitha Oommen *et al.*[1] (2005)	HL, FL	100	19.06/17.32	19.06/17.24	NM	NM	26.21/ 23.75	26.0/23.68	NM	NM
2	B Danborno, A Elukpo *et al.*[6] (2007)	H, HL, HB, FL, FB	400	19.85/18.51	19.93/18.52	8.90/7.82	8.68/7.72	28.39/24.52	26.42/24.70	9.02 / 8.23	9.09/8.11
3	Patel SM, Shah GV *et al.*[7] *2007*	H, FL	502	NM	NM	NM	NM	Male 24.44	Female 22.34	NM	NM
4	Chikhalkar BG *et al.*[3] (2008)	H, FAL, HL, HB, FL, FB	300	18.9		7.53		24.008 with SD 1.420		8.895 with SD 0.703	
5	Patel PN, Tanna JA *et al.*[8] (2012)	H, FL, FB, HL, HB, AS	273	17.758 with SD1.2517		7.917 with SD 0.7926		24.178 with SD 1.809		9.28 with SD 0.865	
6	A. Ibegbu, David *et al.*[9] (2013)	H, HL	600 children	NC	NC	NC	NC	NC	NC	NC	NC
7	Prakash M. Mohite *et al.*[2] (2015)	H, HL, HB, FL	230	Male -19.11, Female -17.4		Male -8.64, female -7.37		Male - 25.86, Female - 22.67		NM	NM
8	Kavyashree AN *et al.*[10] (2015)	H, HL, HB	294	SM- right -18.81, left-18.74 NM-right-18.95, left-18.70 SF-right -17.17, Left-17.21 SM-right-17.30, left-17.31		SM- right -8.24, left-8.00 NM-right-8.24, left-8.10 SF-right -7.24, Left-7.19 SM-right-7.26, left-7.22		NM	NM	NM	NM
9	Rati Tandon *et al.*[5] (2016)	H, HL, HB, FL, FB, DL	497	Male -19.364, Female -17.33		Male-8.312, female-7.247		Male-6.22, Female-3.35		Male-9.95, female - 8.89	
10	Nataraja Moorthy T and Hairunnisa BMAK *et al.*[11] 2017)	W,FL,FB	200	NM	NM	NM	NM	25.25/23.05	25.26/23.05	NM	NM
11	Present study[12] (2018–19)	H, HL,HB, FL, FB	1000	18.90/17.18	18.96/17.11	10.3/9.9	10.29/9.31	25.18/23.39	**25.31/23.1**	**9.39/8.45**	**9.35/8.52**

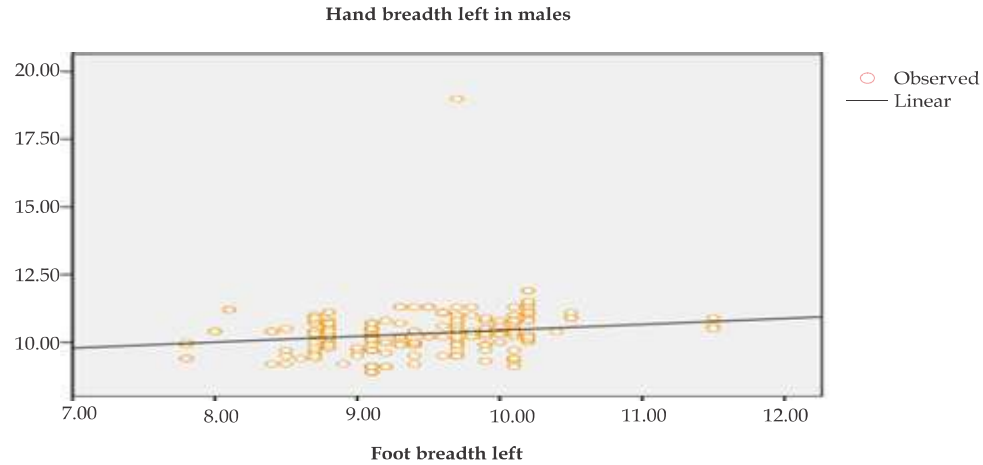
H - Height, **HL -** Hand length, **HB -** Hand breadth, **FL -** Foot length, **FB -** Foot breadth, **PL -** Palm length, **DL -** Digit/finger length, **AS -** Arm span, **FAL -** Forearm length, **NM -** Not measured, **NC -** Not comparable, **NA -** Not available.



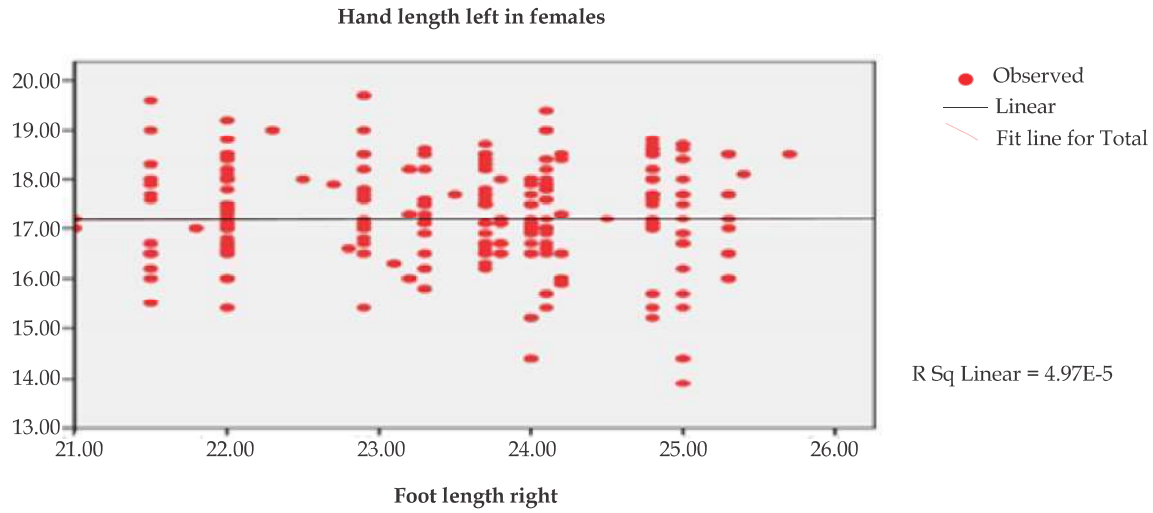
Graph 2: ROC curve of hand length v/s Foot length of left in males



Graph 3: ROC curve of hand breadth v/s Foot breadth of right in males

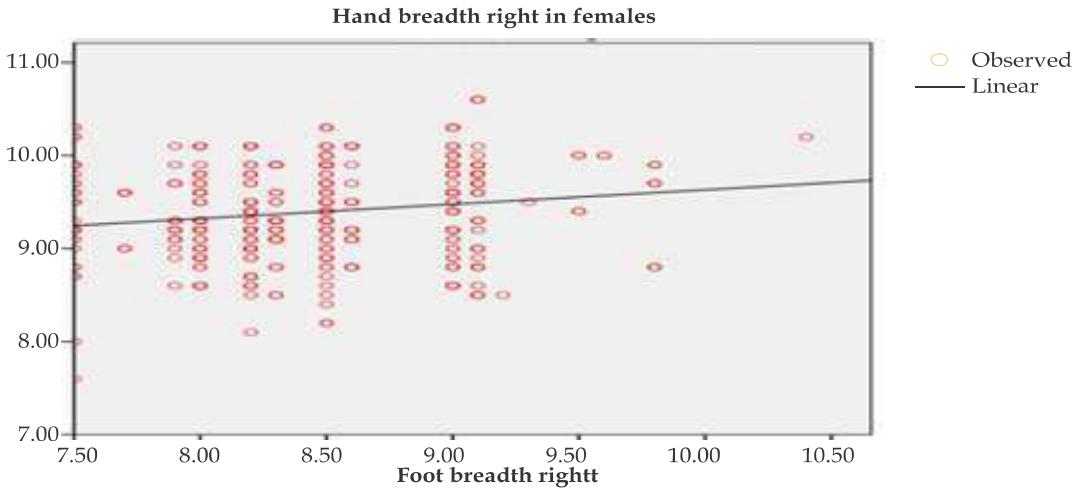


Graph 4: ROC curve of hand breadth v/s Foot breadth of left in males

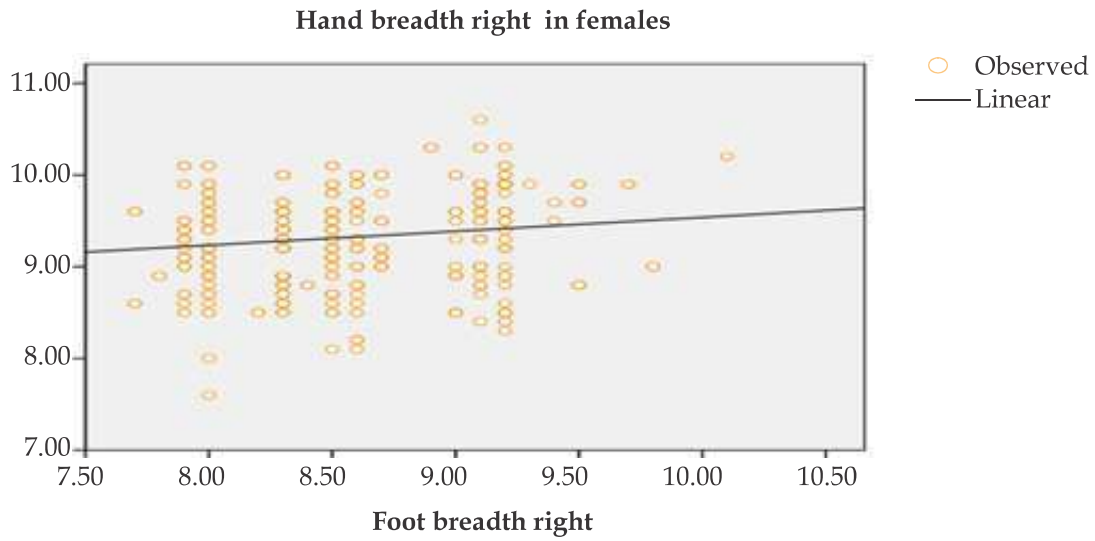


Graph 5: ROC curve of hand length v/s Foot length of right in females

Graph 6: ROC curve of hand length v/s Foot length of left in females



Graph 7: ROC curve of hand breadth v/s Foot breadth of right in females



Graph 8: ROC curve of hand breadth v/s Foot breadth of left in females

Conclusions

1. Highly statistically significant difference was observed in mean foot length and breadth on both sides in both sexes.
2. Statistically significant correlation was observed between hand length and foot length in both sexes.
3. Statistically significant correlation was observed between hand breadth and foot breadth in both sexes.
4. The linear regression formula derived can be used for population between 17 and 20 years but it might be of limited use for children and older people.
5. Equation derived from present study can be used to estimate hand dimensions from foot dimensions and *vice versa* among the Central Indian population.
6. It would be unwise to use the same equations for estimation of hand and foot dimensions for different Indian populations.

Limitations

1. In the present study, age range of only *17–20 years* was considered.
2. Only healthy individuals were included in the study. Hence the data may not be applicable students those with deformities of foot, vertebral column and limbs, contractures, those with h/o of trauma to foot, those with features suggestive of dysmorphic disorder, pregnant females.
3. Applicability of anthropometric measurements in living and deceased individuals may practically differ.
4. The present study is a preliminary one and would be followed up by other studies to address the above limitations.

Conflict of Interest: None.

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