Estimation of stature from footprint and foot outline dimensions in Gujjars of North India

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Introduction

Footprint

- Immense value that possibility recovery at the crime scene
- Barefoot in developing countries like India
- Establishing personal identity

Introduction

Footprint

Conduct a detail of Footprint	Gayer (1904)
Individualization	Robbins (1978), Kennedy et all (2005), Krishan (2007)
Estimation of stature	Robbins (1985,1986), O.P.Jasuja . (1991)

Introduction

- **Provide no. of foot length/stature for various populations**

  Robbins [1984,1986], Barker and Scheuer [1998], Topinard[1976] Martin [1928], Martin and Saller [1959], Pales [1976], Jasuja [198

- **Multiplication factors**

  Robbins [1986], Jasuja[1987], Sharma et all. [1978]

- **High estimation error**

  Krishan [2002], Jasuja[1987], Sharma et all. [1978], Philip [1990], Ozden et all. [2005]

- **Mixed population**

Introduction

Objective

- Estimation of stature from various dimensions from footprint and foot outline in an endogamous group of North India.
- Compare the reliability of stature estimation by division factor method and regression analysis

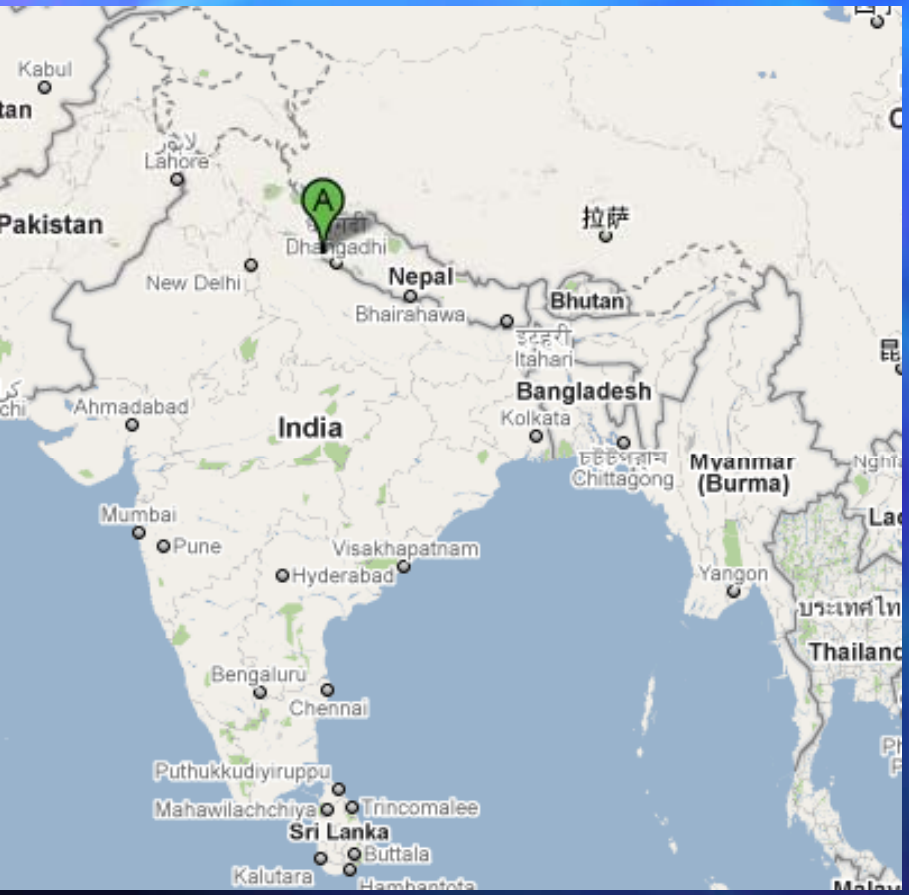
Material and methods

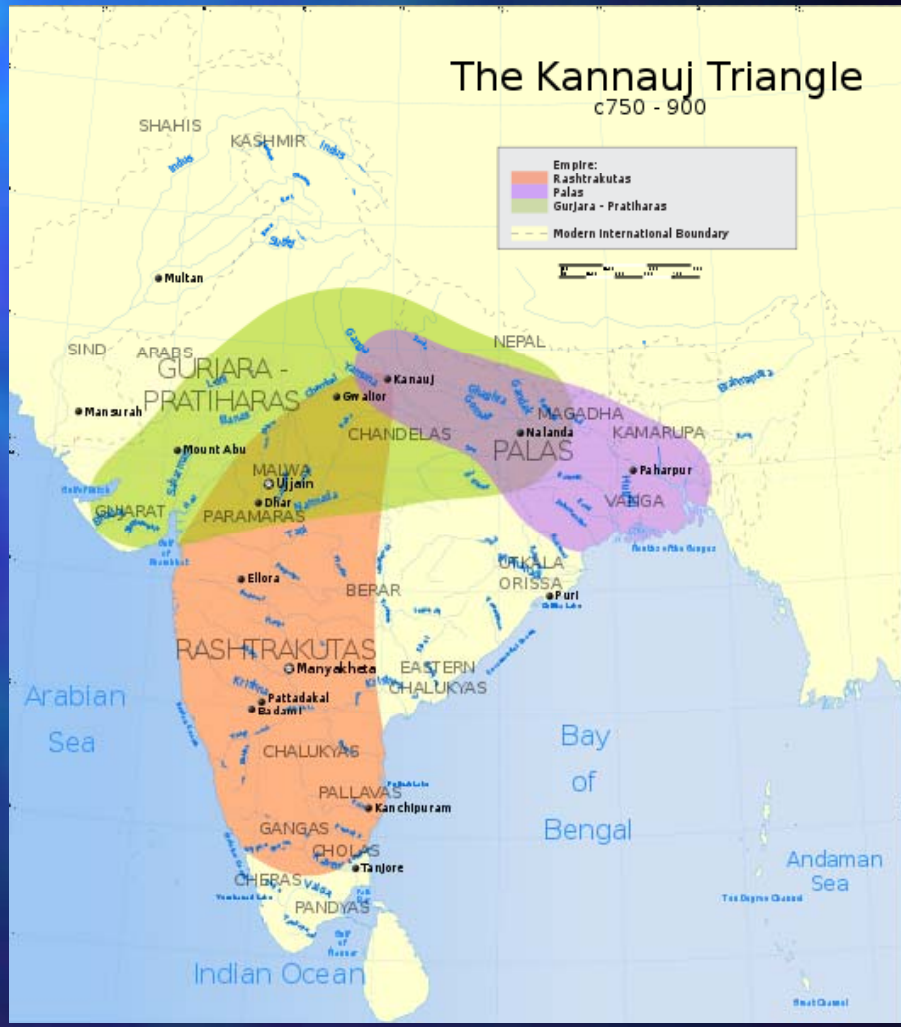
Material and methods

2.1 Sample

- 1040 adult male Gujjars , 18 – 30 yrs.
- inhabiting the Sawalik hills and adjoining plains in sub-Himalayan region (16 village)

Material and methods





Material and methods

- **Gujjars**
  - appeared in Afghanistan, Pakistan and northern India
  - Endoganous gr. strictly marrying within own caste
  - Sedentary and agriculturist
  - Habit of walking bare feet

Material and methods

2.2 Methods

Sj. Clean the sole

Cyclostyling ink

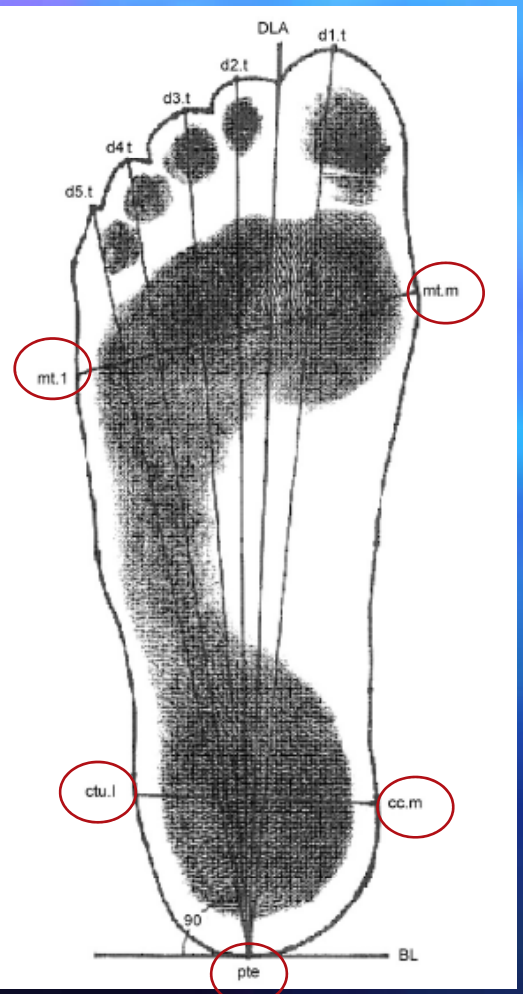
Footprint

Foot Outline

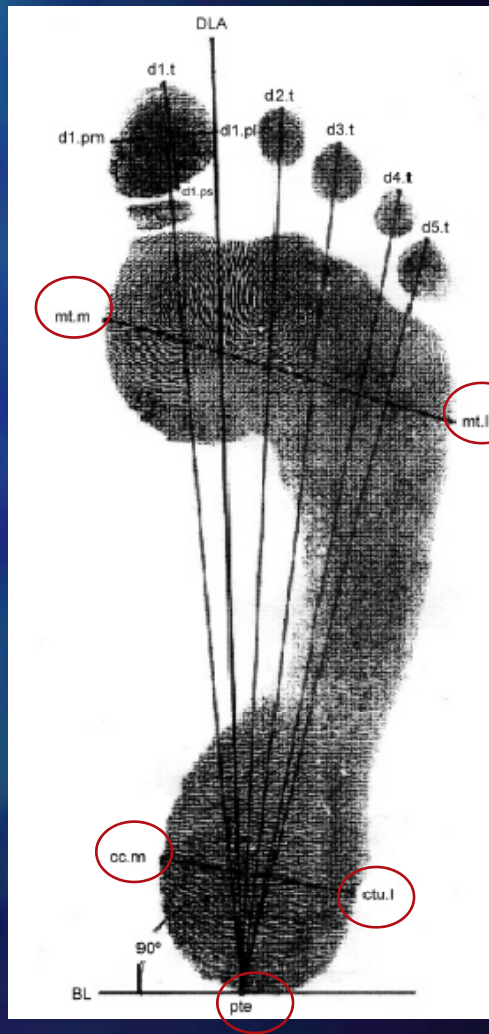
10 measurements

8 measurements

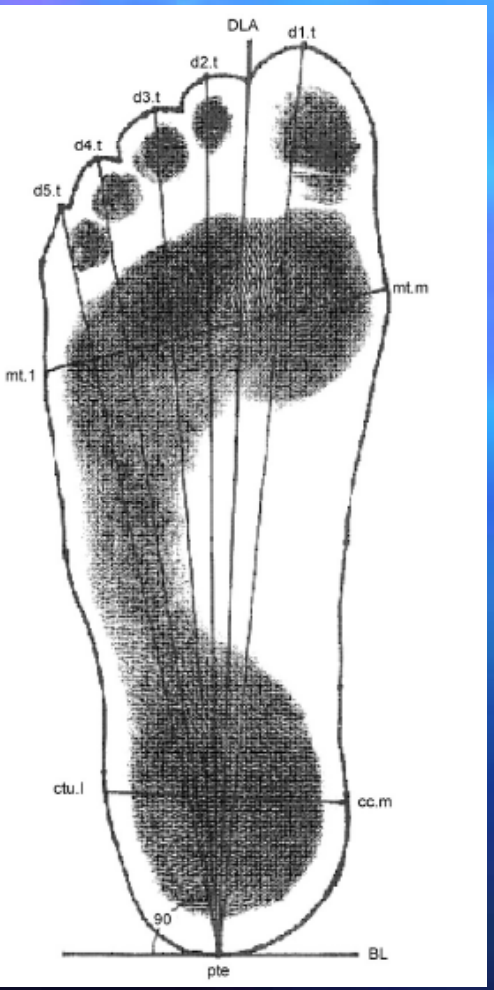
Material and methods



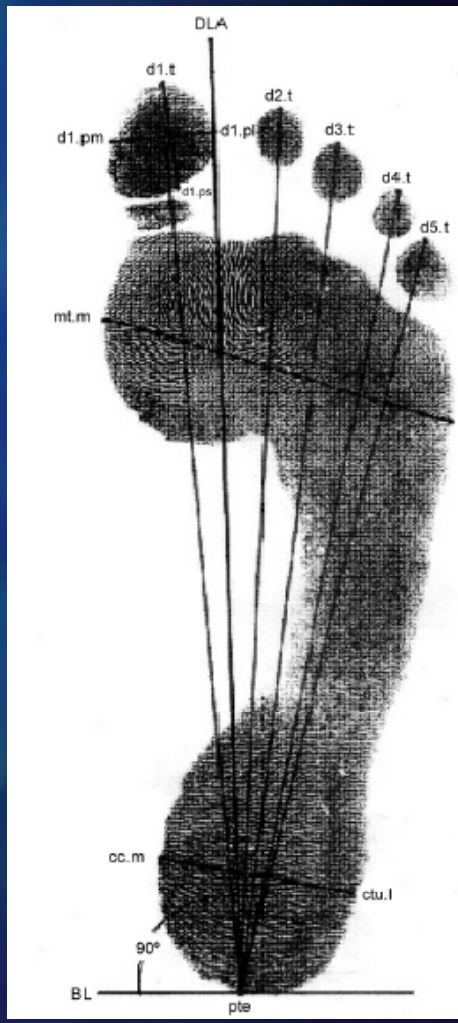
Land mark	Description
pte	Mid – rear heel point
mt.m	Medial metatarsal point
mt.l	Lateral metatarsal point
cc.m	Calcaneal concavity medial
ctu.l	Calcaneal tubercle lateral



Material and methods



Measurement	Foot outline	Footprint
DLA*	√	√
BL*	√	√
T- 1 length	√	√
T- 2 length	√	√
T- 3 length	√	√
T- 4 length	√	√
T- 5 length	√	√
Breadth at ball	√	√
Breadth at heel	√	√
Toe 1 – 5 angle	√	√
Big toe pad length	-	√
Big toe pad breadth	-	√



Material and methods

Technique involved

Bilateral asymmetrical

Paired *t*-test

difference between left and right side within an individual

Correlation

Kerl Pearson correlation

correlation between various length/breadth with stature

Estimation

Division factor Regression analysis

estimation of stature

* * * analyzed using SPSS

Result

Result

Footprint

Table 1
Descriptive statistics of footprint measurements in adult male Gujjars (n = 1040)

Measurement (cm)	Mean		S.D.		Minimum		Maximum	
	Left	Right	Left	Right	Left	Right	Left	Right
T-1 length (d1.t-pte)	24.05	24.13	3.23	3.26	19.6	19.3	27.9	27.3
T-2 length (d2.t-pte)	24.15	23.93	3.12	3.12	18.9	18.8	28.1	28.5
T-3 length (d3.t-pte)	23.45	23.51	2.93	2.99	18.1	18.3	26.8	26.3
T-4 length (d4.t-pte)	21.88	21.34	2.35	2.36	17.1	16.9	25.3	25.9
T-5 length (d5.t-pte)	20.78	20.09	2.30	2.23	16.2	16.5	23.3	23.4
Breadth at ball (mt.m-mt.l)	8.63	8.69	1.98	1.90	6.2	6.3	10.8	11.1
Breadth at heel (cc.m-ctu.l)	5.08	4.92	1.43	1.39	3.1	3.0	8.3	8.4
Big toe pad length (d1.t-d1.ps)	2.98	3.11	0.87	0.89	1.8	1.8	5.6	5.6
Big toe pad breadth (d1.t-d1.pl)	2.48	2.60	0.72	0.68	1.6	1.5	4.3	4.4
Toe 1-5 angle of declination	58°	60°	5.8	5.1	44°	43°	73°	71°

Foot outline

Table 2
Descriptive statistics of foot outline measurements in adult male Gujjars (n = 1040)

Measurement (cm)	Mean		S.D.		Minimum		Maximum	
	Left	Right	Left	Right	Left	Right	Left	Right
T-1 length (d1.t-pte)	25.82	25.43	3.23	3.25	20.2	19.9	28.8	28.3
T-2 length (d2.t-pte)	25.78	25.35	3.42	3.36	19.2	18.9	28.3	28.6
T-3 length (d3.t-pte)	24.97	25.07	2.91	2.82	18.8	18.5	27.3	27.3
T-4 length (d4.t-pte)	23.15	22.93	2.31	2.33	18.6	17.9	24.9	25.3
T-5 length (d5.t-pte)	22.08	21.81	2.29	2.28	16.1	16.4	22.6	22.7
Breadth at ball (mt.m-mt.l)	9.63	9.85	2.21	1.92	6.1	6.4	10.9	11.3
Breadth at heel (cc.m-ctu.l)	5.98	6.15	1.53	1.49	3.2	3.5	8.5	8.4
Toe 1-5 angle of declination	59°	60°	5.3	5.7	40°	40°	76°	72°

Result

Bilateral different

ble 3
eans, standard deviations and values of '*t*' of bilateral differences (left–right) in measurements of footprint and foot outline in adult male Gujjars (n = 104

easurement (cm)	Footprint			Foot outline		
	Mean difference (left–right)	S.D.	*t*-Value	Mean difference (left–right)	S.D.	*t*-Val
length (d1.t-pte)	−0.08	1.12	−1.91	0.39	1.26	2.8
length (d2.t-pte)	0.22	1.32	2.73*	0.43	1.51	1.7
length (d3.t-pte)	−0.06	1.56	−1.56	−0.10	−1.03	−1.3
length (d4.t-pte)	0.54	1.21	1.32	0.22	1.21	2.8
length (d5.t-pte)	0.69	1.12	2.59*	0.27	1.40	2.1
eadth at ball (mt.m-mt.l)	−0.06	1.07	1.92	−0.22	1.51	−2.5
eadth at heel (cc.m-ctu.l)	0.16	0.89	1.58	−0.17	0.79	−1.3
g toe pad length (d1.t-d1.ps)	−0.13	0.76	−1.43	–	–	–
g toe pad breadth (d1.pm-d1.pl)	−0.12	0.40	−1.16	–	–	–
e 1-5 angle of declination	−2°	0.26	−0.89	−1°	0.16	−0.7

$P < 0.01$.

(+) Lt. > Rt. (-) Lt. < Rt.

Result

Division factor and mean error

ble 4
lues of division factor for estimating stature from various measurements on footprint and foot outline in adult male Gujjars ($n = 1040$)

easurement (cm)	Left footprint		Right footprint		Left foot outline		Right foot outline	
	Division factor	Mean error	Division factor	Mean error	Division factor	Mean error	Division factor	Me err
length (d1.t-pte)	0.1424	3.35	0.1427	3.31	O.1512	3.25	0.1497	3.2
length (d2.t-pte)	0.1425	3.37	0.1413	3.29	0.1514	3.38	0.1496	3.3
length (d3.t-pte)	0.1379	3.41	0.1380	3.38	0.1467	3.32	0.1471	3.3
length (d4.t-pte)	0.1272	3.51	0.1254	3.47	0.1347	3.40	0.1340	3.4
length (d5.t-pte)	0.1213	3.46	0.1180	3.44	0.1285	3.41	0.1272	3.4
eadth at ball (mt.m-mt.l)	0.0502	3.96	0.0508	3.98	0.0560	3.86	0.0574	3.9
eadth at heel (cc.m-ctu.l)	0.0296	4.05	0.0288	4.09	0.0347	4.12	0.0358	4.1
g toe pad length (dl.t-d1.ps)	0.0174	4.56	0.0179	4.59	–	–	–	–
g toe pad breadth (d1.pm-d1.pl)	0.0145	4.63	0.0151	4.66	–	–	–	–

Result

Correlation

ble 5
rl Pearson's correlation coefficients between footprint and foot outline measurements with stature ($n = 1040$)

easurement (cm)	Left footprint/stature	Right footprint/stature	Left foot outline/stature	Right foot outline/statur
length (d1.t-pte)	0.87*	0.86*	0.85*	0.86*
length (d2.t-pte)	0.85*	0.87*	0.83*	0.85*
length (d3.t-pte)	0.86*	0.85*	0.84*	0.85*
length (d4.t-pte)	0.85*	0.84*	0.83*	0.83*
length (d5.t-pte)	0.82*	0.82*	0.84*	0.82*
eadth at ball (mt.m-mt.l)	0.66*	0.64*	0.63*	0.66*
eadth at heel (cc.m-ctu.l)	0.57*	0.55*	0.53*	0.52*
g toe pad length (d1.t-d1.ps)	0.41*	0.43*		
g toe pad breadth (d1.pm-d1.pl.)	0.32**	0.30**	–	–
e 1-5 angle of declination	0.09[a]	0.08[a]	0.04[a]	0.08[a]

Values of correlation coefficients are not significant.
Values of correlation coefficients are highly significant ($P < 0.001$).
$P < 0.01$.

- Highly significant correlation in foot length (0.82 – 0.87), $P < 0.001$
- slightly high correlation in bread at ball
- low correlation in bread at heel

Result

Estimation of stature

ble 6
gression equations for estimation of stature through various length/breadth measurements of footprint in adult male Gujjars (n = 1040)

easurement (cm)	Regression equations for left footprint	Mean error	Regressions equations for right footprint	Me err
length (d1.t-pte)	3.689 × T-1 length + 84.013	2.12	3.510 × T-1 length + 87.214	2.1
length (d2.t-pte)	3.864 × T-2 length + 77.783	2.16	3.361 × T-2 length + 91.303	2.1
length (d3.t-pte)	3.520 × T-3 length + 89.146	2.27	3.613 × T-3 length + 84.953	2.3
length (d4.t-pte)	3.869 × T-4 length + 88.013	2.33	3.627 × T-4 length + 94.414	2.3
length (d5.t-pte)	3.985 × T-5 length + 87.753	2.35	3.869 × T-5 length + 94.572	2.3
eadth at ball (mt.m-mt.l)	7.951 × BAB + 102.578	3.11	7.673 × BAB + 105.389	3.1
eadth at heel (ccm.-ctu.l)	9.658 BAH + 122.802	3.64	8.781 × BAH + 126.093	3.6
g toe pad length (d1.t-d1.ps)	12.056 × BTPL + 133.642	3.76	10.969 × BTPL + 133.402	3.7
g toe pad breadth (d1.pm-d1.pl)	15.996 × BTPB + 131.361	3.92	15.064 × BTPB + 135.454	3.8

Stature = a + bx

a measurement

Intercept

Slope

le 7

gression equations for estimation of stature through various length–breadth measurements of foot outline in adult male Gujjars ($n = 1040$)

asurement (cm)	Regression equation for left foot outline	Mean error	Regression equations for right foot outline	Me erro
length (d1.t-pte)	3.255 × T-1 length + 88.458	2.18	3.289 × T-1 length + 87.385	2.1
length (d2.t-pte)	3.569 × T-2 length + 79.885	2.22	3.491 × T-2 length + 83.571	2.2
length (d3.t-pte)	3.621 × T-3 length + 90.467	2.23	3.583 × T-3 length + 80.972	2.2
length (d4.t-pte)	3.710 × T-4 length + 85.030	2.30	3.698 × T-4 length + 84.795	2.2
length (d5.t-pte)	3.993 × T-5 length + 83.894	2.28	3.915 × T-5 length + 85.582	2.2
adth at ball (mt.m-mt.l)	5.394 × BAB + 119.625	3.12	5.414 × BAB + 120.951	3.1
adth at heel (cc.m.-ctu.l)	8.810 × BAH + 118.376	3.61	8.735 × BAH + 120.265	3.5

Discussion

Discussion

- Prediction of stature may be an unachievable and unnecessary goal
- Age control is use in this study

Discussion

Compared with Robbins

le 8
nparison of the means of various footprint and foot outline measurements of the present study with Robbins [12]

asurement (cm)	Footprint data				Foot outline data			
	Present study		Robbins [12]		Present study		Robbins [12]	
	Left	Right	Left	Right	Left	Right	Left	Rig
length (d1.t-pte)	24.05	24.13	23.68	23.59	25.82	25.43	25.10	25.0
length (d2.t-pte)	24.15	23.93	23.56	23.44	25.78	25.35	24.67	24.5
length (d3.t-pte)	23.45	23.51	22.71	22.56	24.97	25.07	23.79	23.6
length (d4.t-pte)	21.88	21.34	21.53	21.36	23.15	22.93	22.57	22.4
length (d5.t-pte)	20.78	20.09	19.94	19.75	22.08	21.81	20.99	20.8
adth at ball (mt.m-mt.l)	08.63	08.69	08.86	08.84	9.63	9.85	09.70	9.7
adth at heel (cc.m-ctu.l)	05.08	04.92	04.93	04.94	5.98	6.15	5.92	5.9
toe pad length (dl.t-dl.ps)	02.98	03.11	02.64	02.59	–	–	–	–
toe pad breadth (dl.pm-dl.pl)	02.48	02.60	02.39	02.42	–	–	–	–
1-5 angle of declination (°)	58	60	60.81	60.60	59	60	58.77	58.6

- Larger value than Robbins
- Separate Lt. and Rt. Foot
- Significant left-side bilateral asymmetrical

Dominant Foot

Discussion

- Avoid inter-observer error while measuring
- Avoid intra-observer error

no sig. intra-observer error

- small mean error (3.29-3.47) that more reliable than the others (3.86 – 4.66)

Discussion

Division factor/Correlation

ble 9
mparison of the values of division factor/ratio index for estimation of stature with Robbins [13] and Philip [44] (T-1 length)

asurement (cm)	Present study (division factor)	Robbins [13] (stature ratio index) (%)	Philip [44] (stat ratio index) (%)
ft footprint length	0.1424	14.387	14.25
ght footprint length	0.1427	14.312	14.28
ft foot outline length	0.1512	15.199	15.25
ght foot outline length	0.1497	15.128	15.23

- Consistent with other study
- Linear and close relationship
- Extreme high correlation from length measurement (0.82 – 0.87)

Discussion

Regression analysis

Table 10
Comparison of actual stature and estimated stature from left T-1 length of footprint using respective regression equations ($n = 1040$)

Value	Minimum estimated stature (cm)	Maximum estimated stature (cm)	Mean estimated stature (cm)
Mean estimated stature	156.31	178.56	172.73
Actual stature	150.81	186.30	172.68

- Under of min and Over of max. but mean value are close
- Mean error of division factor quite higher than regression
- Correlation in various measurements, accuracy and applicability

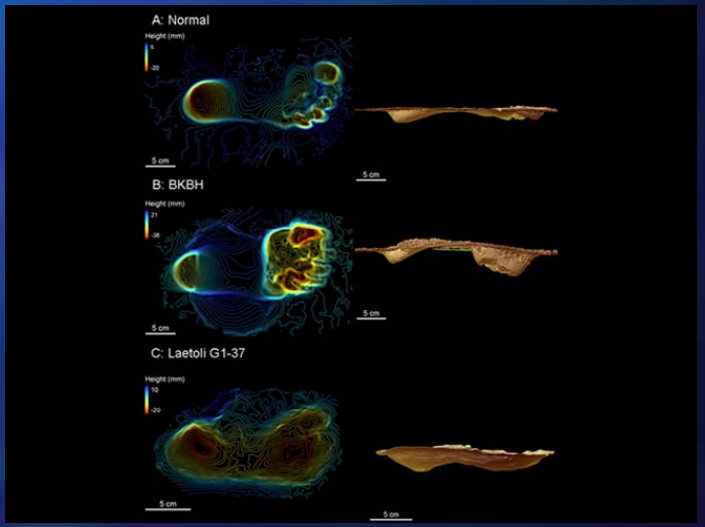
Conclusion

Conclusion

- Footprint and foot outline are utmost important in forensic examination
- Strongly relation and better reliability prediction
- Also careful about population

Critique

- Application in suitable situation
- Sex and age control
- Endogamous population

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