Stature Estimation Based On Lower Limb Dimensions in the Malaysian Population

F. M. Nor, N. Abdullah, Al-M. Mustapa, L. Q. Wen, N. A. Faisal, and D. A. A. Ahmad Nazari

***Abstract*—**Estimation of stature is an important step in developing a biological profile for human identification. It may provide a valuable indicator for unknown individual in a population. The aim of this study was to analyses the relationship between stature and lower limb dimensions in the Malaysian population. The sample comprised 100 corpses, which included 69 males and 31 females between age ranges of 20 to 90 years old. The parameters measured were stature, thigh length, lower leg length, leg length, foot length, foot height and foot breadth. Results showed that mean values in males were significantly higher than those in females ($P < 0.05$). There were significant correlations between lower limb dimensions and stature. Cross-validation of the equation on 100 individuals showed close approximation between known stature and estimated stature. It was concluded that lower limb dimensions were useful for estimation of stature, which should be validated in future studies.

***Keywords*—**Forensic anthropology population data, lower leg length, Malaysian, stature.

I. Introduction

ANTHROPOMETRY may be defined as a technique of expressing the quantitative form of human body. It is recognized as the single most universally applicable, inexpensive and non-invasive technique for assessing the size and proportions of the human body [1]. This technique has been used by anthropologists worldwide to estimate body size and stature for many years [2], [3]. Besides race, age and sex, stature is one of the vital features of identification. Thus, developing a biological profile in stature is an important step for human identification [4].

Stature is usually estimated by employing either the anatomical or mathematical method. The anatomical method is based on a summed height of skeleton or human pieces contributing to stature in human. Nevertheless, the main disadvantage in this method is that nearly complete pieces of bones are needed for stature [5], [6]. On the other hand, the mathematical method makes use of either one or more bone lengths to estimate stature. This method employs bone length, stature tables and regression formulae to estimate total skeletal height from long bones [5], [6]. Most studies have used the mathematical method, which utilised long bones of upper and lower extremities [1]-[9]. Additionally, skull and post cranial elements have also been used for stature estimation [5].

Of all stature predictors, long bones of lower extremities have been extensively used in stature estimation [7]. Studies have shown that femur is more reliable in estimating stature compared with the aforementioned skeletal elements such as metatarsal, metacarpal, calcaneum and fragmentary tibia [2]. Further, femur is less influenced by nutritional and other environmental stresses than the more distal bones of the limbs [4]. The femur in intact state showed the highest correlation with stature, and yields the best accuracy [2] probably because it contributes to the living height the most [4]. For instance, estimation of stature in the Americans, who died in the first half of the 20th century was based on measurements of femur [4].

Stature estimation may be specifically derived from each population. Specific regression for specific population is important to account for inherent population variations [9]-[11] such as genetic and environmental factors [3]. Also, the regressions will take into account human internal factors such as sex and age-related changes [2], [8]. The regression equations used among the indigenous South African population group were derived from fragments of femur [2]. The Bulgarian and Thai populations have also used lower limbs in stature estimation [4], [8]. Thus far, stature estimation had been done mostly by using the regressions based on the European and American population, and these regressions may not be applicable to the Asian population [7]. The fact that there was paucity of study for stature estimation in the Malaysian population; it is certainly warranted to produce regressions based on the population. Hence, the aim of this study was to perform measurements of lower limb parameters for stature estimation in the Malaysian population. The specific objectives were to determine correlations between stature and lower limb parameters, and to produce regressions for stature estimation.

II. Materials and Methods

The human bodies were obtained from two hospitals in Kuala Lumpur, which included the Universiti Kebangsaan Malaysia Medical Centre and the National Institute of Forensic, Hospital Kuala Lumpur. In this study, 100 deceased persons were sampled, which comprised 69 males and 31 females between 20 to 100 years of age. Literature showed nearly 51.2% of the total population in Malaysia was males, and 48.8% was females [12]. The sample represented an admixture of major races namely, Malay, Chinese, Indian and

F. M. Nor is with the Universiti Kebangsaan Malaysia Medical Centre, Cheras, Kuala Lumpur, Malaysia. (phone: 603-91455445; fax: 603-91711673; e-mail: mnfaridah@gmail.com).

N. Abdullah is with the Department of Forensic Medicine, Hospital Kuala Lumpur, Malaysia (e-mail: azilrun@gmail.com).

Al- M. Mustapa, L. Q. Wen, N. A. Faisal, D. A. A Ahmad Nazari are with the Universiti Kebangsaan Malaysia Medical Centre, Cheras, Kuala Lumpur, Malaysia.

the minorities. Bodies with bone pathology, trauma, surgical procedures, decomposed bodies, skeletal abnormality and deformity were excluded from this study.

Six lower limb parameters namely, thigh length (*TL*), lower leg length (*LLL*), leg length (*LL*), foot height (*FH*), foot breadth (*FB*) and foot length (*FL*) were measured. According to the procedure described by the 'International Biological Program' [14], measurements from the left side of the body tend to be more reliable than the right side [13]. Hence, the measurements in this study were taken from the left lower limbs. Measurements were performed by two investigators, and average values were taken. The measurements were taken in centimeters (*cm*), and were measured to two decimal places.

A. Landmarks and Techniques Used in Taking Anthropometric Measurements

- Height-Vertex (Stature): Stature of the body was measured from the vertex with the head in 'Frankfort horizontal plane' to the heel with the body in supine position.
- *Vertex:* It is the highest point on the head when the head is in supine position ('Frankfort plane').
- *Instrument:* Long ruler
- *Technique:* The body was lying supine, and measurement was taken when the body was fully unclothed. The ruler was held on the table, and measurement was taken from the vertex to heel in that position.

B. Thigh Length (TL)

It is the distance from the midpoint of inguinal line to inferior border of patellar. Surface thigh length has been shown to provide the highest correlation with stature.

- *Instrument:* Measuring tape.
- *Technique:* The body was lying supine, and measurement was taken by using a measuring tape. The midpoint of groin was held with the measuring tape by the right hand, and movement of the tape was controlled to extend to the inferior border of patella, in oblique plane with regard to length. No pressure was made on the body surface to reduce possible error in contact measurements.

C. Lower Leg Length (LLL)

It was measured from the lateral knee joint to the heel.

- *Instrument*: Measuring tape.
- *Technique:*The measurement was taken from the lateral knee joint by the right hand, and movement of the tape was controlled to extend to the heel.

D. Leg Length (LL)

It is the distance from the lateral knee joint to lower border of lateral malleolus.

- *Instrument*: Measuring tape.
- *Technique*: The measurement was taken from the lateral knee joint by the right hand, and movement of the tape was controlled to extend to the lateral malleolus.

E. Foot Height (FH)

It is the difference between *LLL* and *LL*.

F. Foot Breadth (FB)

It is the distance between the distal first metatarsal, the prominence of the medial side of foot, and distal fifth metatarsal, the prominence of lateral side of foot.

- *Instrument:* Metal sliding calipers.
- *Technique:* The left foot was held with the heel resting backward, and measurement was taken across the dorsum of foot between the two prominences of side of foot, as in preceding measurement, in oblique plane with regard to length.

G. Foot Length (FL)

It is the distance from the most prominent part of the heel to the distal part of the longest toe (second or first).

- *Instrument:* Measuring tape.
- *Technique:* The measurement was taken across the dorsum of foot between the two prominences of foot as in preceding measurements, in vertical plane with regard to length.

In this study, a statistical package (*SPSS* for windows, Version 20.0) was used to analyze the results [15]. The sample size for human samples was sufficient by using the statistical power calculations [16]. The dependent parameters in the samples were represented by six lower limb parameters. Correlations between lower limb parameters and stature were determined by using the Pearson's correlation test. The regressions were produced based on various combinations of the parameters by stepwise regression analysis. Comparison between measured and estimated statures was analyzed by using paired *T*-test.

III. Results

Table I showed descriptive statistics for lower limb parameters in males and females. The mean age for males in this study was 59 years (n = 69) and 64 years in females (n = 31), and generally, the females were nearly 5 years older than the males (Table I). The lower limb dimensions showed normal data distribution by using the Kolmogorov-Smirnov test. The mean values of lower limb parameters and their standard deviations were significantly higher in males than in females ($P < 0.05$) (Table I). However, the values may not be entirely representative in this study as males have a higher number of samples compared to females.

TABLE I
DESCRIPTIVE STATISTICS FOR LOWER LIMB DIMENSIONS, AGE AND STATURE IN MALES AND FEMALES *ST* = STATURE, *TL* = THIGH LENGTH, *LLL* = LOWER LEG LENGTH, *FL* = FOOT LENGTH, *FB* = FOOT BREADTH, *FH* = FOOT HEIGHT

	Males (*n* = 69)				Females (*n* = 31)			
	Mean	*SD*	*Min*	*Max*	Mean	*SD*	*Min*	*Max*
Age	59.1	14.9	20	88	64.2	14.9	28	90
St	164.8	7.2	149	186	152.6	6.3	140	165.3
TL	44.4	3.2	36.2	54.0	40.5	2.7	35.4	45.0
LLL	47.2	2.8	41.4	56.4	43.4	2.6	38.8	49.3
LL	41.5	2.7	36.2	49.7	38.2	2.4	33.4	42.4
FL	24.0	1.6	20.6	28.0	21.9	1.3	20.1	26.5
FB	9.2	0.5	7.7	10.5	8.4	0.6	7.4	9.4
FH	5.7	1.0	3.7	10.6	5.3	1.0	3.2	7.8

TABLE II
THE PEARSON'S CORRELATION ANALYSIS BETWEEN LOWER LIMB PARAMETERS AND STATURE

Parameters	*R*
LLL	0.776**
LL	0.730**
FL	0.690**
TL	0.675**
FB	0.517**
FH	0.322**

$**P < 0.01$

The Pearson's correlation showed good correlations between lower limb parameters and stature, in which *LLL* exhibited the highest correlation ($R = 0.776$) followed by *LL*, *FL*, *TL*, *FB* and *FH* ($R = 0.322$) (Table II). A summary of linear regressions in males, females and combined sex was tabulated in Table III. By using the linear regression, the stature can be estimated from mutilated or fragmentary body parts by using the regression:

$$y \text{ (stature)} = b \text{ (constant)} + a \text{ (regression coefficient of the independent parameter) } \chi \quad (1)$$

The regression in combined sex showed that *LLL* has a coefficient variance (R^2) of 60%. This means that 60% of variation was contributed by the parameters, while the remaining 40% of variation was due to random error (Table III). The variance was subsequently reduced for each parameter that is, *LL* (53%), *FL* (48%), and *TL* (46%), respectively. The regression based on *LLL* in combined sex showed the lowest standard error of estimation (*SEE*) i.e. 5.68 compared to all other parameters (Table III).

The multiple regression analysis had produced regressions by using various combinations of all six parameters. In combined sex, the multiple regressions showed lower *SEE* (4.87 to 4.90) (Table IV) than that in linear regressions (5.68 to 8.53) (Table III). In males, the regressions based on *TL*, *LLL* and *FB* showed the lowest *SEE* (4.48) ($P < 0.01$) (Table IV), while in females, the regression based on *LLL*, *LL*, *FL* and *FH* showed the least *SEE* (5.13) ($P < 0.01$) (Table IV). The *SEE* was comparatively slightly higher in females (5.13) than in males (4.48), which could be explained by a higher number of males in this study ($n = 69$) than females ($n = 31$). Further explanation was provided for by greater variance in females (43%) than in males (63%), in which 43% of variation was contributed by the parameters in females compared to 63% of variation contributed by the parameters in males.

TABLE III
LINEAR REGRESSION EQUATIONS FOR STATURE (*CM*) ESTIMATION IN MALES, FEMALES AND COMBINED SEX

	Equations	*R*	R^2	*SEE*
	Male			
LLL	79.412 + 1.809 *LLL*	0.72	0.52**	5.03
LL	95.102 + 1.677 *LL*	0.63	0.40**	5.64
TL	106.039 + 1.324 *TL*	0.60	0.37**	5.79
FL	102.707 + 2.588 *FL*	0.60	0.36**	5.83
FH	151.692 + 2.280 *FH*	0.32	0.10**	6.89
FB	131.427 + 3.613 *FB*	0.29	0.08**	6.96
	Female			
LL	98.158 + 1.426 *LL*	0.54	0.30**	5.45
LLL	96.922 + 1.282 *LLL*	0.53	0.28**	5.49
FL	111.417 + 1.875 *FL*	0.39	0.16*	5.97
TL	121.256 + 0.773 *TL*	0.33	0.11	6.13
FB	132.215 + 2.416 *FB*	0.23	0.05	6.32
FH	148.276 + 0.815 *FH*	0.14	0.02	6.43
	Combined sex			
LLL	63.845 + 2.111 *LLL*	0.78	0.60**	5.68
LL	74.255 + 2.141 *LL*	0.73	0.53**	6.16
FL	81.912 + 3.385 *FL*	0.69	0.48**	6.52
TL	88.074 + 1.688 *TL*	0.67	0.46**	6.64
FH	145.6 + 2.74 *FH*	0.32	0.10**	8.53
FB	100.56 + 6.72 *FB*	0.52	0.27**	7.71

$*P < 0.05$, $**P < 0.01$

TABLE IV
MULTIPLE REGRESSIONS FOR STATURE ESTIMATION IN MALES

	Equations	*R*	R^2	*SEE*
	Male			
1	*Y*= 45.06 + 0.56 *TL* + 0.95 *LLL* + 0.309 *LL* + 0.318 *FL*) + 2.74 (*FB*) + 0.79 (*FH*)	0.80	0.64**	4.52
2	*Y* = 44.64 +0.60 (*TL*)+0.98 (*LLL*)+0.35 (*LL*)+2.99 (*FB*) 0.86(*FH*)	0.79	0.63**	4.50
3	*Y* = 45.39 +0.61 (*TL*)+1.29 (*LLL*)+3.03 (*FB*)+0.53(*FH*)	0.79	0.63**	4.49
4	*Y* = 46.30 + 0.62 (*TL*)+1.37 (*LLL*)+ 2.85 (*FB*)	0.79	0.63**	4.48
	Female			
1	*Y*= 72.26 + 0.15 (*TL*) - 6.04 (*LLL*)+ 7.41 (*LL*)+ 1.45 (*FL*) - 1.32 (*FB*)+ 6.17 (*FH*)	0.67	0.45**	5.27
2	*Y* = 76 - 6.43 (*LLL*) + 7.86 (*LL*) + 1.49 (*FL*) - 1.42 (*FB*) + 6.56 (*FH*)	0.67	0.45**	5.18
3	*Y* = 72.28 - 5.39 (*LLL*) + 6.79 (*LL*) + 1.15 (*FL*) + 5.61 (*FH*)	0.66	0.43**	5.13
4	*Y* = 87 - 5.12 (*LLL*) + 6.71 (*LL*) + 5.97 (*FH*)	0.62	0.39**	5.23
	Combined sex			
1	*Y* =38.05 + 0.61 (*TL*) + 0.87 (*LLL*) + 0.44 (*LL*) + 0.52 (*FL*) + 2.65 (*FB*) + 0.51 (*FH*)	0.85	0.72**	4.90
2	*Y* =38.272 + 0 .61 (*TL*) + 1.11 (*LLL*) + 0.21 (*LL*) + 0.57 (*FL*) + 2.60 (*FB*)	0.85	0.72**	4.89
3	*Y* =38.310 + 0.62 (*TL*) + 1.28 (*LLL*) + 0.57 (*FL*) + 2.69 (*FB*)	0.85	0.72**	4.87
4	*Y* =38.426 + 0.68 (*TL*) + 1.41 (*LLL*) + 3.14 (*FB*)	0.84	0.71**	4.89

$**P < 0.01$

The regressions were subsequently cross-validated against the study sample. The results showed that there was no significant difference between known stature and estimated stature by using paired *T*-test ($P < 0.05$). The mean difference between known stature and estimated stature was 0.86cm in males, which ranged from 1.1*cm* to 2.4*cm*. The mean difference between known stature and estimated stature was 1.96*cm* in females, which ranged from 4.4*cm* to 5.1*cm* (Table V). By using the independent sample *T*-test, it was found that there was no significant difference in stature estimation in both males and females (Table VI). Further, it was observed that there was no significant difference between the values measured by two independent observers by using paired *T*-test ($P < 0.05$). This confirmed the usefulness of the regressions produced for stature estimation in the Malaysian population.

TABLE V
DESCRIPTIVE STATISTICS OF MEAN VALUES OF KNOWN STATURE AND ESTIMATED STATURE IN MALES AND FEMALES

		N	Mean	*SD*	*SEM*
Known stature	Male	69	164.8	7.2	0.8
	Female	31	152.6	6.3	1.1
Estimated stature	Male	69	163.9	6.4	0.7
	Female	31	154.5	4.9	0.8

The table showed only slight difference between known and estimated stature in both males and females.

TABLE VI
INDEPENDENT SAMPLE *T*-TEST BETWEEN KNOWN AND ESTIMATED STATURE IN MALES AND FEMALES

	t	*df*	*Sig. (2-tailed)*
Known stature	8.10	98	0.87
Estimated stature	7.18	98	0.12

The table showed no significant difference between known and estimated stature in males and females.

IV. DISCUSSION

Previous research studies have studied different parts of the body to establish a relationship between stature and body segments. Studies have shown that lower extremity have a greater association with body stature than that with upper extremity [3]. This study has performed measurements on lower limb parameters to relate with stature, in which several anatomical landmarks have been carefully chosen on intact body surfaces. The results showed that there were close approximation between estimated stature and known stature in the Malaysian population in males, females and combined sex.

The lower limb parameters exhibited significant correlations with stature, which was in accordance with that in [3]. From the parameters, foot breadth and foot height had shown significant correlations with stature, in accordance with that in [17]-[21]. Comparatively, the *LLL* had provided the highest accuracy for stature estimation. The regressions were cross-validated on the study sample, which showed close approximation of stature between known and estimated values, which was in agreement with that in [13].

Table VII showed the comparable correlation coefficients of foot length and foot breadth with stature in the present study and as in [13]. Foot breadth values were comparable in males and females in both studies. However, foot length showed lower correlations in this study than in [13] (Table VII). The discrepancies could be attributed to different equipments used in their measurements, in which measuring a measuring tape and sliding calipers have been used in this study and in [13], respectively. Nevertheless, foot length in males showed a good correlation ($R = 0.598$) in this study, although slightly lower than in [13] ($R = 0.741$) (Table VII).

TABLE VII
COMPARISON OF CORRELATION BETWEEN STATURE AND ANTHROPOMETRIC MEASUREMENTS FROM KRISHNAN AND SHARMA (2007) [13] AND THE PRESENT STUDY *ST* = STATURE, *FB* = FOOT BREADTH, *FL* = FOOT LENGTH

	Krishnan and Sharma (2007) [13]		The present study	
Parameter	Male	Female	Male	Female
	St	*St*	*St*	*St*
	Pearson correlation (*R*)			
FB	0.324	0.323	0.287	0.230
FL	0.741	0.734	0.598	0.394

Table VIII showed regression equations and *SEE* in this study and as in [3] in males and females. Generally, the equations based on *TL*, *LLL* and *LL* showed comparable values of variance (R^2) and *SEE* in both studies (Table VIII), although the regressions based on *LLL* and *LL* in females showed slightly higher *SEE* in this study that as in [3] (Table VIII). Table IX showed regressions based on foot length and foot breadth in his study and as in [13] in males and females. Comparatively, the *SEE* from the regressions was only slightly higher in this study than those by [13]. In brief, the regressions achieved in this study had confirmed the usefulness of lower leg parameters for stature estimation in the Malaysian population. It will, therefore be of great help to the forensic and physical anthropologists to proceed with stature estimation based on lower limb parameters.

TABLE VIII
COMPARISON OF DIRECT REGRESSION ANALYSIS INCLUDING *R*, R^2 AND *SEE* FROM OZASLAN *ET AL.* (2003) AND THE PRESENT STUDY *TL* = THIGH LENGTH, *LLL* = LOWER LEG LENGTH, *LL* = LEG LENGTH

		TL	*LLL*	*LL*
	Ozaslan *et al.* (2003)			
Males	*R*	0.50	0.75	0.74
	R^2	0.20	0.56	0.55
	SEE	5.94	4.39	4.46
Females	*R*	0.23	0.80	0.79
	R^2	0.05	0.65	0.63
	SEE	6.31	3.86	3.93
	The present study			
Males	*R*	0.60	0.72	0.63
	R^2	0.37	0.52	0.40
	SEE	5.79	5.03	5.64
Females	*R*	0.33	0.53	0.54
	R^2	0.11	0.28	0.30
	SEE	6.13	5.49	5.45

TABLE IX
COMPARISON OF *SEE* WITH MULTIPLE REGRESSION EQUATIONS FOR ESTIMATION OF STATURE (*CM*) FROM KRISHNAN AND SHARMA (2007) [13] AND THE PRESENT STUDY *ST* = STATURE, *FB* = FOOT BREADTH, *FL* = FOOT LENGTH

Krishnan and Sharma (2007) [13]		The present study	
Male	*SEE*	Male	*SEE*
St = 99.59 + 1.51 *FL* + 3.29 *FB*	3.02	*St* = 93.05 + 2.44 *FL* + 1.44 *FB*	5.82
Female		Female	
St = 79.36 + 2.60 *FL* + 2.11 *FB*	2.98	*St* = 109.22 + 1.75 *FL* + 0.59 *FB*	6.07

Admittedly, the literature had documented variations that exist between ethnic origins and racial affiliation in relation to body dimensions, and its relations to locomotor pattern, lifestyle and energy expenditure [22], [23]. The Malaysian people, in generally is mostly short in stature, lead an active lifestyle and lives in a hot climate compared to the European and North American people, who are generally taller, led a slightly different lifestyle and lived in cold climate. Comparatively, the energy expenditure in cold climate is much less than that in a hot climate. The environmental factor may have some influence in people's life style, which consequently lead to differences in bone configuration and dimension in the population. This is the main reason that studies need to be done in a population to represent its people with specific equations for stature estimation.

There was a recent encounter by the author and the police at a crime scene, whereby a leg has been found in an abandoned apartment house. The remaining parts of the body were dismembered, and packed in separate plastic bags in different parts of the house. The identification of the deceased was based on stature estimation for identification, besides resorting to *DNA* analysis and physical characteristics. At the time, stature was estimated by resorting to the established regressions based on the European and North American populations, as there were no regressions based on the Malaysian population. This case is sufficient evidence to warrant a research on stature estimation for the population, which will be useful particularly, for identification of dismembered remains to help the police in their investigations.

ACKNOWLEDGMENT

The authors thanked the Universiti Kebangsaan Malaysia Medical Centre for funding this research study. Great thanks are due to the staff in the Forensic Unit, Universiti Kebangsaan Malaysia Medical Centre and the National Institute of Forensic Medicine, Hospital Kuala Lumpur for their assistance in doing the research.

REFERENCES

[1] J. Sen, S. Ghosh, "Estimation of stature from foot length and foot breadth among the Rajbanshi: An indigenous population of North Bengal," Forensic Sci. Int., vol. 181, no. 1-3, pp. 55 e1-55 e6, 2008.
[2] M.A. Bidmos, "Estimation of stature using fragmentary femora in indigenous South Africans," Int. J. Legal Med., vol. 122, pp. 293-299, 2007.
[3] A. Ozaslan, M.Y. Iscan, I. Ozaslan, H. Tugcu, S. Koc, "Estimation of stature from body parts," Forensic Sci. Int., vol. 3501, pp. 1-6, 2003.
[4] P. Mahakkanukrauh, P. Khanpetch, S. Prasitwattanseree, K. Vichairat, D.T. Case, "Stature estimation from long bone lengths in a Thai Population," Forensic Sci. Int., vol. 210, pp. 279 e1-279e7, 2011.
[5] M.A. Bidmos, "Stature Reconstruction Using Fragmentary Femora in South Africans of European Descent," J. Forensic Sci., vol. 53, no. 5, pp. 1044-1048, 2008.
[6] M.R. Dayal, M. Steyn, K.L. Kuykendall, "Stature estimation from bones of South African whites," S. Afr. J. Sci., vol. 104, no. 3-4, pp. 124-128, 2008.
[7] T.W. Auyeung, J.S.W. Lee, T. Kwok, J. Leung, P.C. Leung, J. Woo, "Estimation of stature by measuring fibula and ulna bone length in 2443 Older Adults," J. Nutrition Health Aging, vol. 13, pp. 931-936, 2009.
[8] D. Radoinova, K. Tenekedjiev, Y. Yordanov, "Stature Estimation from long bone lengths in Bulgarians," H.O.M.O., vol. 52, no. 3, pp. 221-232, 2002.
[9] J.K. Lundy, "Regression equations for estimating living stature from long limb bones in South Africa Negro," S. Afr. J. Sci., vol. 79, pp. 337-338, 1983.
[10] J.K. Lundy, M.R. Feldesman, "Revised equations for estimating living stature from long bones of South African Negro," S. Afr. J. Sci., vol. 83, pp. 54-55, 1987.
[11] M. Trotter, G.C. Glesser, "Estimation of stature from long bones of American Whites and Negroes," Am. J. Phys. Anthropol., vol. 10, pp. 463-514, 1952.
[12] Department of Statistics, Malaysia, Preliminary Court Report, Population and Housing Census, Malaysia, http://www.statistics.gov.my/, 2010.
[13] K. Krishnan, A. Sharma, "Estimation of stature from dimension of hands and feet in North Indian Population," J. Forensic Leg. Med., vol. 14, no. 6, pp.327-332, 2007.
[14] S.J. Ulijaszek, C.G.N. Mascie-Taylor, "Anthropometry: The individual and the population," Cambridge: University Press Cambridge, 1994, vol. xiii, pp. 213.
[15] SPSS for windows (Version 20.0), SPSS Science, Inc. Chicago, 2005.
[16] M. Bland, "An introduction to medical statistics," Oxford: Oxford University Press, 1995.
[17] S.G. Sanli, E.D. Kizilkanat, N. Boyan, "Stature estimation based on hand length and foot length," Clin. Anat., vol. 18,pp. 589-596, 2005.
[18] H. Ozden, Y. Balci, C. Demirustu, A. Turgut, M. Ertugrul,Stature and sex estimate using foot and shoe dimensions," Forensic Sci. Int., vol. 147, no. 2-3, pp. 181-184, 2005.
[19] S.K. Saxena, "A study of correlations and estimation of stature from hand length, hand breadth and sole length," Anthropol. Anz., vol. 42, no. 4, pp. 241-246, 1984.
[20] C.C. Gordon, J.E. Buikstra, "Linear Models for the prediction of stature from foot and boot dimensions," J. Forensic Sci., vol. 37, pp. 771-782, 1992.
[21] K. Ashizawa, C. Kumakura, A. Kusumoto, S. Narasaki, "Relative foot size and shape to general body size in Javanese, Filipinas and Japanese with special reference to habitual footwear types," Ann. Hum. Biol., vol. 24, no. 2, pp. 117-129, 1997.
[22] H.L. Muncie Jr, J. Sobal, J.M. Hoopes, J.H. Tenney, J. W. Warren, "A practical method of estimating stature of bedridden female nursing home patients," J. Am. Geriartr. Soc., vol. 35, pp. 285-289, 1987.
[23] M. Chiba, K. Terazawa, "Estimation of stature from somatometry of skull," Forensic Sci. Int., vol. 97, pp. 87-92, 1998.