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Estimation of Stature of School Aged Children from Kazaure Emirate Using Percutaneous Humeral Length

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ABSTRACT
Stature has been one the most important factors in the description of the individual characteristics for a long time. The aim of this study was to estimate stature using percutaneous humeral length in school children aged 5-12 years from Kazaure emirate. It was a cross-sectional study. All measurements were taken from 863 (432males and 431 females) primary school pupils aged 5-12 years. The height and humeral length of the participants were measured. Results showed a sexual dimorphism in height where males had higher mean value for height than females (p=0.041). In the general population, right humeral length (RHML) correlated strongly with height and left humeral length (LHML) (r=0.921; r=0.992) respectively at p=0.01. Similarly, leftt humeral length (LHML) correlated strongly with height and right humeral length (RHML) (r=0.920; r=0.992) respectively. Correlation in female population showed a strong positive correlation between RHML and height (r=0.927); LHML and height (r=0.926); LHML and RHML (r=0.993) respectively with statistical significant difference p=0.01. Correlation in male population showed a strong positive correlation between RHML and height (r=0.916); LHML and height (r=0.915); LHML and RHML (r=0.991) respectively with statistical significant difference p=0.01. A simple linear regression equation that can be used to estimate the stature of this given population using the length of right and left humerus respectively is Height = (3.89) RHML + 23.84, and Height = (4.0) LHML + 23.44. Conclusively, percutaneous humeral length can be a reliable predicting factor for the stature of the studied population.

Keywords: Stature; Estimation; Humerus length; Age; Kazaure emirate

INTRODUCTION
Assessing height of an individual from measurement of different parts of the body has always been one of the most interesting issue to anthropologists. Stature has been one of the most important factors in the description of the individual characteristics for a long time (Jit and Singh, 1956; Charnalia, 1961; .Athawale, 1963; Joshi *et al*., 1964; Shroff and Vare, 1979; Saxena, 1984). The estimation of height from various parameters has been performed in various studies (Mahakkanukrauh *et al*., 2011; Akhlaghi *et al*., 2012; Akhlaghi *et al*., 2012; Ahmed, 2013; Sládek *et al*., 2014; Rastogi *et al*., 2014). Anthropometric data from different races, age and sex groups can be useful in designing a product and in addition it can reduce human errors (Chaichankul *et al*., 2011; Yue *et al*., 2011; Tseng *et al*., 2014). The results of these studies are helpful in different branches such as forensic medicine, surgery, ergonomics and biomedical engineering (Eftekhar vaghefi *et al*., 2014). Furthermore, identification of dismembered human remains that are frequently found in cases of mass disasters and criminal is a challenging task for the medico-legal experts (Blau and Briggs, 2011).

Also, the living stature can be predicted by anatomical and mathematical techniques (Sheikhazadi *et al*., 2015). Bones as the body segments were mostly used for stature estimation in different studies (Sládek *et al*., 2014; Meshram *et al*., 2014; Lee *et al*., 2014; Macaluso Jr and Lucena, 2014), however percutaneous length of bones was evaluated in several studies (Shah *et al*., 2015; Moorthy *et al*., 2014; Ragavan and Chandran, 2015; Kuppast, 2011; Pal and Datta, 2014). Some researches could evaluate the relation between stature and upper arm length (UAL) or percutaneous humerus length and define formulas for this relationship in different age groups. According to the results of these studies, the reliability and prediction power of the derived formulae were different (Salles *et al*., 2009; Banik *et al*., 2012; Mall *et al*., 2001).

Arm morphology is an important element to determining upper limb movement behaviour (Adamo *et al*., 2012). The design of devices for orthopaedic goals depends on the anatomical and physical characteristics of the bones. Also, measurements of arm dimensions in the different populations can be assigned in design of industry products such as orthopaedic prostheses (Lädermann *et al*., 2012). These researches can be helpful for prediction of stature in individuals with disproportionate growth abnormalities and skeletal dysplasia or height loss during surgical procedures on the spine (Hepper *et al*., 1965). The objective of this research is to predict person's height using length of a humerus measured from a living pupil. This is helpful to individuals that have either amputated leg, or crippled, or cannot stand erect due to backbone problem, or with poliomyelitis etc.

MATERIALS AND METHODS

Experimental Site

Kazaure is located in the Northern part of Kano State among the 27 local governments of Jigawa State. It lies between longitude 12°30;' to 12° 45' and latitude 8° 15' to 8° 30 North and East respectively. It covers a land area of about 1,780 kilometers square. It is bordered to the north by Daura (Katsina State), West by Ingawa (Katsina State), East by Babura (Jigawa State) and to the South by Dambatta (Kano State) (Olofin, 1987; Ayodele, 2000).The area belongs to the Sudan Savanna Vegetation. Rainfall begins between May and June and ends around September and October. The main annual rainfall is about 600mm with the highest input during the months of July and August. Mean annual temperature is about 26°C but mean monthly value ranges between 22°C in the coldest months (December and January) and 31°C in the hottest months of April and May (Olofin, 1987).

Study design

The study was a cross-sectional survey that involved 863 (432 males and 431 females) primary school pupils. Age range was from 5-12 years. The height of the subjects was measured using a stadiometer, and readings were recorded to the nearest 0.1cm. In all subjects, right and left humerus length (length of arm) was measured in 90 degrees flexed elbow in persons in standing position. The length of arm was defined as the distance between acromion end of clavicle and olecranon process and measurement was done using a sliding caliper, readings were recorded to the nearest 0.1 cm (Vallois, 1965).

Selection Criteria

Inclusion criteria

Subject must be of age range 5-12 years, Primary school pupil, From Kazaure emirate, Apparently healthy, Inform consent from guardians

Exclusion criteria

Any subject outside inclusion criteria

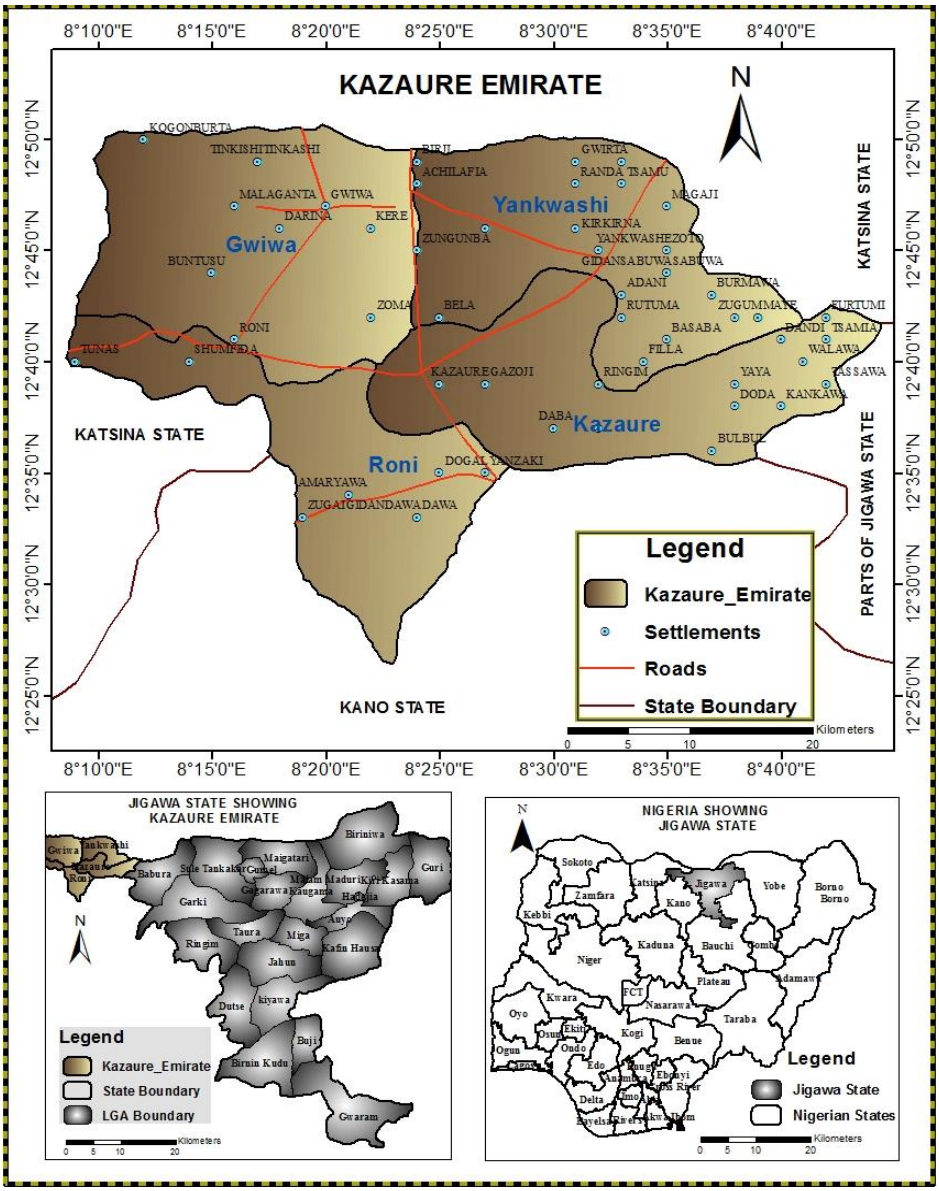

Figure 1: Map of Kazaure emirate.

Statistical Analysis

Independent *t*-test was used for evaluation of differences between means. The correlation between height and arm length was evaluated, and a simple linear regression model was used for predicting stature of the population. Data were expressed as mean and standard deviation (SD) for descriptive analysis. Analyses were done using statistical package for service solutions (SPSS) version 20.0 at $P<0.05$.

RESULTS

The result in Table 1 showed the minimum and maximum values for height, age and humeral lengths of the general population and their means at Kazaure emirate. It shows that values for height and humeral lengths increase with increase in age. Thus indicating growth of body parts is virtually proportionate to increase in age.

Table 2 shows the minimum and maximum values for height, age and humeral lengths of the female population and their means at Kazaure emirate. It shows that values for height and humeral lengths increase with increase in age. Thus indicating growth of body parts is virtually proportionate to increase in age. Minimum and maximum values for height, age and humeral lengths of the male population and their means at Kazaure emirate (Table 3). It shows that values for height and humeral lengths increase with increase in age. Thus indicating growth of body parts is virtually proportionate to increase in age.

The result in Table 4 indicated independent t-test between male and female pupils at Kazaure emirate with the males having higher height than the females counterpart with statistical significant difference, p=0.041. Similarly, male had higher RHML and LHML than the female counterparts with no statistical significant difference. This indicates that males growth is a bit faster than in females. Table 5 shows the correlation of the anthropometric variables for the general population at Kazaure emirate with age correlating positively with height (r=0.982), RHML correlating with height (r=0.921) and age (r=0.927), respectively. Similarly, LHML correlated with height (0.920), age (r=0.926) and RHML (r=0.992) respectively. This shows that growth of body parts is related to increase in age of an individual. That is, as age progresses, likewise growth of body parts progresses exponentially. Correlation of the anthropometric variables for the female population at Kazaure emirate with age correlating positively with height (r=0.984), RHML correlating with height (r=0.921) and age (r=0.927), respectively (Table 6) .Similarly, LHML correlated with height (0.920), age (r=0.926) and RHML (r=0.992) respectively. This indicates that growth of body parts is directly proportional with increase in age. Table 7 shows the correlation of the anthropometric variables for the male population at Kazaure emirate with age correlating positively with height (r=0.985), RHML correlating with height (r=0.916) and age (r=0.928), respectively. Similarly, LHML correlated with height (0.915), age (r=0.926) and RHML (r=0.991) respectively. This indicates that growth of body parts is directly proportional with increase in age. Table 8 shows linear regression equation for estimation of stature using the anthropometric variable. HT=a+bX, where a= constant, b=coefficient of correlation, X=RHML or LHML; HT = (3.89) RHML + 23.84; HT= (4.0) LHML + 23.44.

Table 1: Height, age and humeral lengths of general pupils population at Kazaure emirate

Variables	N	Minimum	Maximum	Mean±SD
Height (cm)	863	101.00	147.00	126.92±12.66
Age (years)	863	5	12	8.50±2.31
Right Humeral Length (cm)	863	19.00	31.60	25.93±2.94
Left Humeral Length (cm)	863	19.00	32.00	25.96±2.92

N=number of participants (subjects)

Table 2: Height, age and humeral lengths of female pupils population at Kazaure emirate

Variables	N	Minimum	Maximum	Mean±SD
Height (cm)	427	103.00	145.00	126.03±12.88
Age (years)	427	5	12	8.49±2.32
Right Humeral Length (cm)	427	19.00	31.20	25.79±2.94
Left Humeral Length (cm)	427	19.00	31.50	25.81±2.91

N=number of participants (subjects)

Table 3: Height, age and humeral lengths of male pupils population at Kazaure emirate

Variables	N	Minimum	Maximum	Mean±SD
Height (cm)	436	101.00	147.00	127.79±12.39
Age (yrs)	436	5	12	8.50±2.30
Right Humeral Length (cm)	436	19.60	31.60	26.06±2.94
Left Humeral Length (cm)	436	20.00	32.00	26.10±2.93

N=number of participants (subjects)

Table 4: Independent sample t-test

Variables	Sex	N	Mean±SD	F	t	p-value
Height (cm)	F	427	126.03±12.88	0.64	-2.042	0.041
	M	436	127.79±12.39			
Right Humeral	F	427	25.79±2.94	.143	-1.331	0.184
Length (cm)	M	436	26.06±2.94			
Left Humeral	F	427	25.81±2.91	.523	-1.477	0.140
Length (cm)	M	436	26.10±2.93			

N=number of participants (subjects)

Table 5: Correlations of the General Population (n=863)

	Height	Age	RHML	LHML
Height (cm)	1			
Age(yrs)	0.982**	1		
RHML (cm)	0.921**	0.927**	1	
LHML (cm)	0.920**	0.926**	0.992**	1

**. Correlation is significant at the 0.01 level

Table 6: Correlations for Female Population (n=427)

	Height	Age	RHML	LHML
Height (cm)	1			
Age(yrs)	0.984**	1		
RHML (cm)	0.927**	0.929**	1	
LHML (cm)	0.926**	0.927**	0.993**	1

**. Correlation is significant at the 0.01 level

Table 7: Correlations for Male Population (n=436)

	Height	Age	RHML	LHML
Height (cm)	1			
Age(yrs)	0.985**	1		
RHML (cm)	0.916**	0.928**	1	
LHML (cm)	0.915**	0.926**	0.991**	1

**. Correlation is significant at the 0.01 level

Table 8: Linear regression

Variables	R value	R^2	SEE
RHML	0.935	0.875	4.325
LHML	0.932	0.869	4.427

P<0.0001

Note: HT=a+bX, where a= constant, b=coefficient of correlation, X=RHML or LHML
HT = (3.89) RHML + 23. 84, HT= (4.0) LHML + 23.44

DISCUSSION

Identification is the most important issue in forensic investigation. The long bones and their relation with stature can be useful in forensic identifications. In living populations percutaneous length of bones can be used for prediction of stature in different populations and different age groups (Shah *et al*., 2015; Moorthy *et al*., 2014; Ragavan and Chandran, 2015; Kuppast, 2011; Pal and Datta, 2014; Sheikhazadi *et al*., 2015). This is in line with this study where percutaneous humeral length was used in estimating stature of school children aged 5-12 years from Kazaure emirate, Jigawa State, Nigeria. In this study, it was observed that the heights and humeral lengths of the pupils were within the same range with the males having higher heights and the females.This is is line with the studies by Pena Reyes *et al*. (2002), Donald (2002), Al-Sendi *et al*. (2003), Kharyal and Nath (2008), Ilayperuma, (2010), Ezekie *et al*. (2015), that showed males had higher height, weight and BMI than the females.

The correlation between the stature and long bone length was best for the humerus in females and the tibia in male. In this present study, humerus bone was found to be good for both sexes. In another study in China, Zheng *et al*.) (2011), evaluated the relation of upper limb bones including tibia and fibula with stature. The measurements were taken from computed radiography and mathematical models were used to establish the formulae in teenagers' population (from 14 to 18 years old). Study by De Mendonça (2000) conducted on 200 individuals (100 males and 100 females) from the northern districts of Portugal. In this study, height and bones length were measured directly. Estimation of stature is obtained by applying a mathematical method based on a multivariable linear regression between the height of lengths of humerus and femur.

Study by Nath and Krishan (1990) for predicting the stature from UAL in 276 Hindu (Baniya) females of Delhi (ages 15-22 years). The SEE was 4.95 whereas in comparison to our study the SEE was 4.325 for RHML and 4.427 for LHML respectively indicating high level of accuracy in the present study due to lower SEE level. In another study conducted by Nath *et al*. (1991), 160 male Rajputs of Tehsil Chakrata; district Dehradun, Uttar Pradesh (aged 16-35 years) were evaluated for the relation between UAL (humeral length) and stature. SEE for this study was 5.12 while in comparison to present study SEE was 4.325 for RHML and 4.427 for LHML respectively indicating high level of reliability.

In this study, upper arm length or percutaneous humerus length was evaluated in 5-12-year-old school children from Kazaure emirate. The results of other studies were similar to the present study in the evaluation of length of arm.

CONCLUSION:

From the study it was observed that percutaneous humerus length or upper arm length (UAL) was a reliable predictor of stature/height of school children aged 5-12 years from Kazaure emirate.

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REFERENCES

Adamo, D. E., Scotland, S. and Martin, B. J. (2012). Upper limb kinesthetic asymmetries: gender and handedness effects. *Neuroscience Letters*, 516(2):188-92.

Ahmed, A. A. (2013). Estimation of stature using lower limb measurements in Sudanese Arabs. *Journal of Forensic and Legal Medicine*, 20(5):483-8.

Akhlaghi, M., Hajibeygi, M., Zamani, N. and Moradi, B. (2012). Estimationof stature from upper limb anthropometry in Iranianpopulation. *Journal of Forensic and Legal Medicine*, 19(5):280-4.

Akhlaghi, M., Sheikhazadi, A., Ebrahimnia, A., Hedayati, M., Nazparvar, B. and Anar, S.H.S. (2012). The value of radius bone in predictionof sex and height in the Iranian population. *Journal of Forensic and Legal Medicine*, 19(4):219-22.

Al-Sendi, A.M., Shetty, P. and Musaiger, A.O. (2003). Anthropometric and body composition indicators of Bahraini adolescents. *Annals of Human Biology*, 30(4): 367–379.

Athawale, M. (1963). Estimation of height from lengths of forearmbones. A study of one hundred Maharashtrian male adultsof ages between twenty-five and thirty years. *American Journal of Physical Anthropology*, 21(2):105-12.

Ayodele, A. (2000). *Kazaure emirate: Historical and social perspectives*. More Blessing Printers, Kano. 1-22.

Banik, S.D., Azcorra, H., Valentín, G., Bogin, B. and Dickinson, F. (2012). Estimation of stature from upper arm length in children aged4.0 to 6.92 years in Merida, Yucatan. *The Indian Journal of Paediatrics*, 79(5):640-6.

Batra, A. P. S. (2011). Estimation of stature from upper arm length in north Indians–an anthropometric study. *Indian Journal of Fundamental and Applied Life Sciences*, 1(4):151-4.

Blau, S. and Briggs, C.A. (2011). The role of forensic anthropology in DisasterVictim Identification (DVI). *Forensic Science International*, 205(1):29-35.

Chaichankul, C., Tanavalee A. and Itiravivong, P. (2011). Anthropometric measurements of knee joints in Thai population: correlationto the sizing of current knee prostheses. *The Knee*, 18(1):5-10.

Charnalia, V. (1961). Anthropological study of the foot and its relationshipto stature in different castes and tribes of Pondicherry state. *Journal of Anatomical Society of India*, 10:26-30.

De Mendonça, M. (2000). Estimation of height from the length of long bones in a Portuguese adult population. *American Journal of Physical Anthropology*, 112(1):39-48.

Donald, R. M. (2002). Gender and age differences in the relationship between body mass index and perceived weight: Exploring the paradox. *International Journal of Men's Health*, 1(1): 31-42.

Eftekhar vaghefi, S.H., Elyasi, L., Akbari, H., Rashidzade, A., Zeiai, A. and Eftekhar Vaghefi, S. (2014). Determination of ratio of claviclebone length to height in men and women 20-30 years old of Kerman. *Rehabilitation Medicine*, 3(1):8-14.

Ezekie, J., Anibeze, C. I. P., Uloneme, G.C. and Anyanwu, G. E. (2015). Height estimation of the Igbos using cephalo-facial anthropometry. *International Journal of Current Microbiology and Applied Sciences*, 4(6): 305-316.

Hepper, N., Black, L. and Fowler, W. (1965). Relationships of lung volume to height and arm span in normal subjects and in patients with spinal deformity. *The American Review of Respiratory Disease*, 91:356.

Ilayperuma, I. (2010). On the prediction of person s stature from cranial dimensions. *International Journal of Morphology*, 28(4): 1135-1140.

Jit, I. and Singh, S. (1956). Estimation of stature from clavicles. *The Indian Journal of Medical Research*, 44(1):137-55.

Joshi, N., Patel, M. and Dongre, A. (1964). Regression equation of heightfrom ulnar length. *The Indian Journal of Medical Research*, 52:1088.

Kharyal, A. and Nath, S. (2008). Estimation of stature from maxillo-facial measurements among Brahmins of Himachal Pradesh. *Indian Journal of Forensic Odontology*, 1(1): 13-16.

Kuppast, N. (2011). Estimation of Stature from Percutaneous Ulna Length. *Medico-Legal Update*, 11(2):87-9.

Lädermann, A., Walch, G., Lubbeke, A., Drake GN, Melis B, Bacle G, et al.(2012) Influence of arm lengthening in reverse shoulder arthroplasty. *Journal of Shoulder and Elbow Surgery*, 21(3):336-41.

Lee, J.H., Kim, Y.S., Lee, U.Y., Park, D. K., Jeong, Y.K. and Lee, N. S. (2014). Stature estimation from partial measurements andmaximum length of lower limb bones in Koreans. *Australian Journal of Forensic Sciences*, 46(3):330-8.

Macaluso Jr, P.J. and Lucena, J. (2014). Stature estimation from radiographicsternum length in a contemporary Spanish population. *International Journal of Legal Medicine*, 128(5):845-51.

Mahakkanukrauh, P., Khanpetch, P., Prasitwattanseree, S.,Vicariate, K. and Case, D.T. (2011). Stature estimation from long bone lengths in a Thai population. *Forensic Science International*, 210(1):279. E1-e7.

Mall, G., Hubig, M., Büttner, A., Kuznik, J., Penning, R. and Graw, M. (2001). Sex determination and estimation of stature from the long bones of the arm. *Forensic Science International*, 117(1):23-30.

Meshram, M. M., Rahule, A.S. and Bashir, M. (2014). Stature estimationfrom the length of humerus in Vidarbha region of Maharashtra. *Medico-Legal Update*, 14(1):127.

Moorthy, T.N., Ling, A.Y., Sarippudin, S. A. and Nik Hassan, N. F. (2014). Estimation of stature from footprint and foot outline measurements in Malaysian Chinese. *Australian Journal of Forensic Sciences*, 46(2):136-59.

Nath, S. and Krishan, G. (1990). Determination of stature by using the percutaneous measurement of the upper and the lower limb bone among the Hindu females of Delhi. *Journal of Anthropological Survey of India*, 39:151-66.

Nath, S., Garg, R. and Krishan, G. (1991). Estimation of stature through percutaneous measurements of upper and lower limbs among male Rajputs of Dehradun. *Journal of the Indian Anthropological Society*, 26:245-9.

Olofin, A.E. (1987). Some aspect of physical geography of the Kano region and related human responses: department lecture note. *Series no. 1*.

Pal, D.C. and Datta, A. K. (2014). Estimation of stature from radius length in living adult Bengali males. *Indian Journal of Basic and Applied Medical Research*, 3(2):380-389.

Pena-Reyes, M., Cardenas, B.E., Cahuich, M., Barragan, A. and Malina, R. (2002). Growth status of children 6-12 years from two different geographic regions of Mexico. *Annals of Human Biology*, 29 (1): 11 – 25.

Petrovečki, V., Mayer, D., Šlaus, M., Strinović, D. and Škavić, J. (2007). Prediction of stature based on radiographic measurements of cadaver long bones: a study of the Croatian population. *Journal of Forensic Sciences*, 52(3):547-52.

Ragavan, S. and Chandran, M. (2015) Stature estimation from handlength and foot length in adults-a regional study in Chennai,Tamilnadu. *Indian Journal of Forensic Medicine and Toxicology*, 9(1):205-11.

Rastogi, P., Murali, R. and Rastogi, S. (2014). Hand Biometrics-A tool for gender and Stature estimation. *Journal of Forensic Medicine and Toxicology*, 31(1&2):87-90.

Salles, A., Carvalho, C., Silva, D. and Santana, L. (2009). Reconstruction of humeral length from measurements of its proximal and distal fragments. *Brazilian Journal of Morphological Sciences*, 26(2):55-61.

Saxena, S. (1984). A study of correlations and estimation of staturefrom hand length, hand breadth and sole length. *Anthropologischer Anzeiger*, 42(4):271-6.

Shadan, N., Tahmineh, M., Tahereh, A., Ali, A. and Gholamreza, H. (2014). Determination of Stature from Upper Arm Length in Medical Students from Iranian population. *Anatomical Sciences*, 11(3): 135-139.

Shah, T., Patel, M., Nath, S. and Menon, S. K. (2015). A model for construction of height and sex from shoulder width, arm length and foot length by regression method. *Journal of Forensic Science and Criminology*, 2(4):402.

Sheikhazadi, A., Hassanzadeh, G., Mokhtari, T., Sheikhazadi, E., Saberi Anary, S.H. and Qoreishy, M. (2015). Stature estimation frompercutaneous Tibia height: study of Iranian medical students. *Joint and Bone Science Journal*, 2(2):121-8.

Shroff, A. and Vare, A. (1979). Determination of height from length of superiorextremity and its segments. *Journal of Anatomical Society of India*, 28:53.

Sládek, V., Macháček, J., Ruff, C., Schuplerová, E., Přichystalová, R. and Hora, M. (2014). Stature estimation from long bones in the Early Medieval population at Pohansko (Czech Republic): Applicability of regression equations. *American Journal of Physical Anthropology*, 242.

Tseng, C.Y., Wang, I.J. and Chu, C.H. (2014). Parametric modelling of 3D human faces using anthropometric data. *Industrial Engineering and Engineering Management*, 491-5.

Vallois, H. (1965). Anthropometric techniques. *Current Anthropology*, 6(2):127-43.

Yue, B., Varadarajan, K.M., Ai, S., Tang, T., Rubash, H. E. and Li, G. (2011). Differences of knee anthropometry between Chinese and white men and women. *The Journal of Arthroplasty*, 26(1):124-30.

Zheng, T., Huang, Y., Zhang, J., Zhao, H., Wang, Y. and Shu, Y. (2011). Stature estimation of teenagers by limb long bones with computerized radiography. *Fa yi xue za zhi*, 27(3):178-81.