Available online freely at www.isisn.org

Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2020 17(4): 4261-4268. **OPEN ACCESS**

Estimation of Stature Using Sacrum and Coccyx Computed Tomography of Libyan Population in Benghazi

Fatma Youssef Faraht[1], [1] Ahmad Ali Hamed[2] and Elham Elshawadfy Megahed

[1]Forensic Medicine and Clinical Toxicology Department, Faculty of Medicine, Zagazig University, **Egypt**
[2]Forensic Medical Examiner in Judicial Experience and Research Center Ajdabiya- **Libya**

***Correspondence: abadali2012@gmail.com** **Received 11-05-2020, Revised: 30-05-2020, Accepted: 02-06-2020 e-Published: 30-12-2020**

Computed Tomography (CT)is a non-invasive diagnostic tool that can be used for external and internal examination without causing damage. Stature is positively correlated with long bone length and the most accurate estimates of stature are obtained when undamaged long bones of known sex and ethnic identity are available. However, it is not always possible to obtain intact long bones especially in mass disasters. This study aimed to develop equations for calculating stature from measurements of sacrum and coccyx byCT of Libyan population. Subjects and methods: A cross-sectional study was carried out in Radiological center of Aljala Hospital of Benghazi and Benghazi Medical Center in Libya on 120 subjects who were divided into 60 males and 60 females .The period of the study was six months. The actual stature of subjects in study was estimated Sacral and coccygeal parameters including ASL, PSL, ASCL, PSCL, CLS, LAS, and MDB were measured using CTThen Pearson's correlation coefficient was used to assess the correlation between the actual stature of subjects in study and these CT parameters. Finally regression equations were calculated for estimation of stature from sacral and coccygeal measurements. There was high significant correlation between stature and different studied parameters except ASW. All these parameters were positively correlated with stature except MTDB that was negatively correlated with stature By simple linear regression equations, stature can be estimated from sacral and coccygeal parameters that were proven to be statistically significant with highest R2including ASCL, PSCL, CLS and LAS. There was no statistical significant difference between mean values of actual stature and the stature estimated using regression equations that proves their success. The regression equations presented in this study are useful for forensic estimation of the stature of Libyan individuals, particularly in cases where better predictors such as the long bones are not available. Stature can be estimated from sacral and coccygeal parameters that were proven to be statistically significant with highest R^2 such as ASCL, PSCL, CLS and LAS. There was no statistical significant difference founded between mean values of actual stature and the stature estimated using regression equations that proves success of regression formula.

Keywords: Sacrum, Coccyx, Stature, ASL,MDB,ASWand CT.

INTRODUCTION

The identification of incomplete, mutilatedor decomposed bodies is an important part of a forensic investigation (Akhlaghi et al.2016).Defining attributes from skeletal elements such as ancestry, sex, age and stature may help forensic anthropologists to identify an individual (Benazzi et al. 2009). Sacrum is meaning “sacred/holy bone” and has high sexual dimorphism (Gómez-Valdés et al. 2011). It is consisted of fusion of five vertebrae and forms the postero-superior wall of the pelvic cavity being wedged between the two hip bones (Standring, 2015).Coccyx, tailbone, is considered to be a vestigial remnant of a tail and is the final segment of human backbone (Woon and Stringer, 2012).The length of the coccyx varies among individuals but approximately 10% of this difference is related to height. About 70-80 % of people showing coccyx consist of 3-5 vertebrae (Karayol et al. 2019).

Stature is positively correlated with long bone length and the most accurate estimation of stature is obtained when undamaged long bones of known sex and ethnic identity are available (Akhlaghi et al. 2016).Previous studies examined stature estimation of the sacrum and/or coccyx in different populations (Karakas et al.2011; Pininski and Brits, 2014; Torimitsu et al. 2014). However, it is not always possible to obtain intact long bones especially in mass disasters (Saukko and Knight, 2016).

So, stature is one of the important aspects of biological profile for an unknown individual in forensic anthropology. The science of estimating stature from bones was well known since the 19th century till present moment (Ismail et al.2018).

Computed tomography has influenced numerous fields since its inception in 1970. CT has been used in numerous medical-related domains including biology, biological anthropology, archaeology, forensic science and material science (Cotter et al. 2015).As a non-invasive diagnostic tool, CT has many advantages. The digitized object can be examined externally and internally, without causing damage to the object. Investigations are repeatable and verifiable at any time and digital data or 3D-printed hard copies of the object can be easily replicated and shared within the scientific community (Zhang et al. 2017).

Advanced imaging modalities can aid in personal identification with much higher accuracy than conventional methods (D'Eyrameset al. 2009).Anthropologically, CT has been utilized in the study of skulls and in the forensic context as an additional resource in the process of identification. Previous studies reported that personal identification by conventional methods has already been proved but with variable efficacies (Kallalli et al. 2016).

Therefore, this study aimed to develop equations for predicting stature from measurements of sacrum and coccyx byCT of Libyan population.

MATERIALS AND METHODS

A cross-sectional study was carried out in Radiological center of Aljala Hospital of Benghazi and Benghazi Medical Centerin Libya on 120 subjects who were divided into 60 males and 60 females .The period of the study was six months. Approval of the study was obtained from the Department of Forensic Medicine&Clinical Toxicology and Institutional Review Board (IRB), Faculty of Medicine, Zagazig University. Written informed consent for participation was taken from each research subject.

Inclusion and exclusion criteria:

This study included age from ≥ 21 to 60 years.While exclusion criteria included age < 21or >60 years, patients with known congenital or acquired skeletal diseases presence of pelvic fracture, pelvic bony malformation, pelvic bone tumor, sacra showing pathological fusion and presence of lumbar vertebral fracture or fixation.

Tools and instruments:

Computed tomography was carried out on Somatom definition as 128 slice CT Machine by Siemens Germany Ltd. The scanning area included the region of the whole pelvis. The scanning protocol was as follows: collimation of1 mm, reconstruction interval of 1 mm, tube voltage of 120 kV, tube current of 110 mA, and scanning time of 0.3 s. images. All measurements on the sacrum and coccyx were recorded using the mid-sagittal plane images and 3D reconstructed images(Zhan et al. 2018).

Methods for stature estimation:

1-Living length (stature) estimation:

Stature was taken according to Paulis (2015) in which each subject was asked to stand barefooted on flat plate form of the stadiometer with heels placed together, on standing with both hands in the side of the thighs, the head oriented in Frankfort horizontal plane against the vertical board by aligning the horizontal bar on the contact point of the vertex of the head The movable rod of the anthropometer was brought into contact with the vertex in the mid sagittal plane. The measurements were repeated and the mean measures were recorded (by one observer) in order to avoid inter-observer errors. All measures were recorded in centimeters to the nearest millimeters.

2- Sacral and coccygeal CT parameters measurements:

The following parameters were measured including anterior sacral length (ASL), posterior sacral length (PSL) , anterior sacrococcygeal length (ASCL), Posterior sacrococcygeal length (PSCL), anterior sacral width (ASW) , Curved length of sacrum (CLS), Length of auricular surface (LAS); mid sagittal diameter of the base (MDB)and maximum transverse diameter of the base (MTDB)ASL, PSL, ASCL, PSCL and CLS were measured from mid-sagittal plane images While ASW, MDB, MTDB and LAS were measured from 3D reconstructed images(Mishra et al. 2003 and Torimitsu et al. 2014).

3- Correlation between stature& sacral and coccygeal measurements:

Pearson's correlation coefficient was calculated for assessing correlation between the stature and sacralwithcoccygeal measurements (Franklin et al. 2014).

4- Calculation of estimated stature:

Regression equations were calculated for estimation of stature from these measurements (Zhan et al.2018).

Statistical analysis:

Data were collected throughout history, basic clinical examination and laboratory investigations. Outcome measures were coded and analyzed using Microsoft Excel software. Data were then imported into Statistical Package of Social Sciences (SPSS version 20.0)(IBM,2017). Correlation was assessed by Pearson's correlation. Prediction formula was assessed by simple and multiple linear regressions. P value was set at <0.05 for significant, P <0.01 for high significant , P <0.001 for very high significant and P >0.05 for non-significant results

RESULTS

Demographic data of the studied groups*:*

I-Age and stature distribution between males and females:

There was non statistical significant difference (p>0.05) between the mean age of males (44.43±7.88) and that of females (41.86±8.3), while there was very high statistical significant difference (p<0.001) between mean stature of males (176.92±3.69) and that of females (160.15±5.79**)** using student - t test (Table 1).

II-Stature estimation using sacral and coccygeal parameters:

1--Simple linear regression model for prediction of male and female participants' stature from sacral and coccygeal parameters:

By simple linear regression equations, stature was estimated from sacral and coccygeal parameters that were proven to be statistically very high significant with highest R^2 (coefficient of determination) including PSCL , LAS, CLS and ASCL (Table 2).

Table (1): Age and living stature distribution between males and females using student -t- test:

N=60	Male	Female	T	P
Age	44.43±7.88	41.86±8.3	1.736	0.085
Stature	176.92±3.69	160.15±5.79	18.899	0.00**

**:very high significant(P value<0.001) N: number of subjects in each group
:t: student -t-Test P: probability.

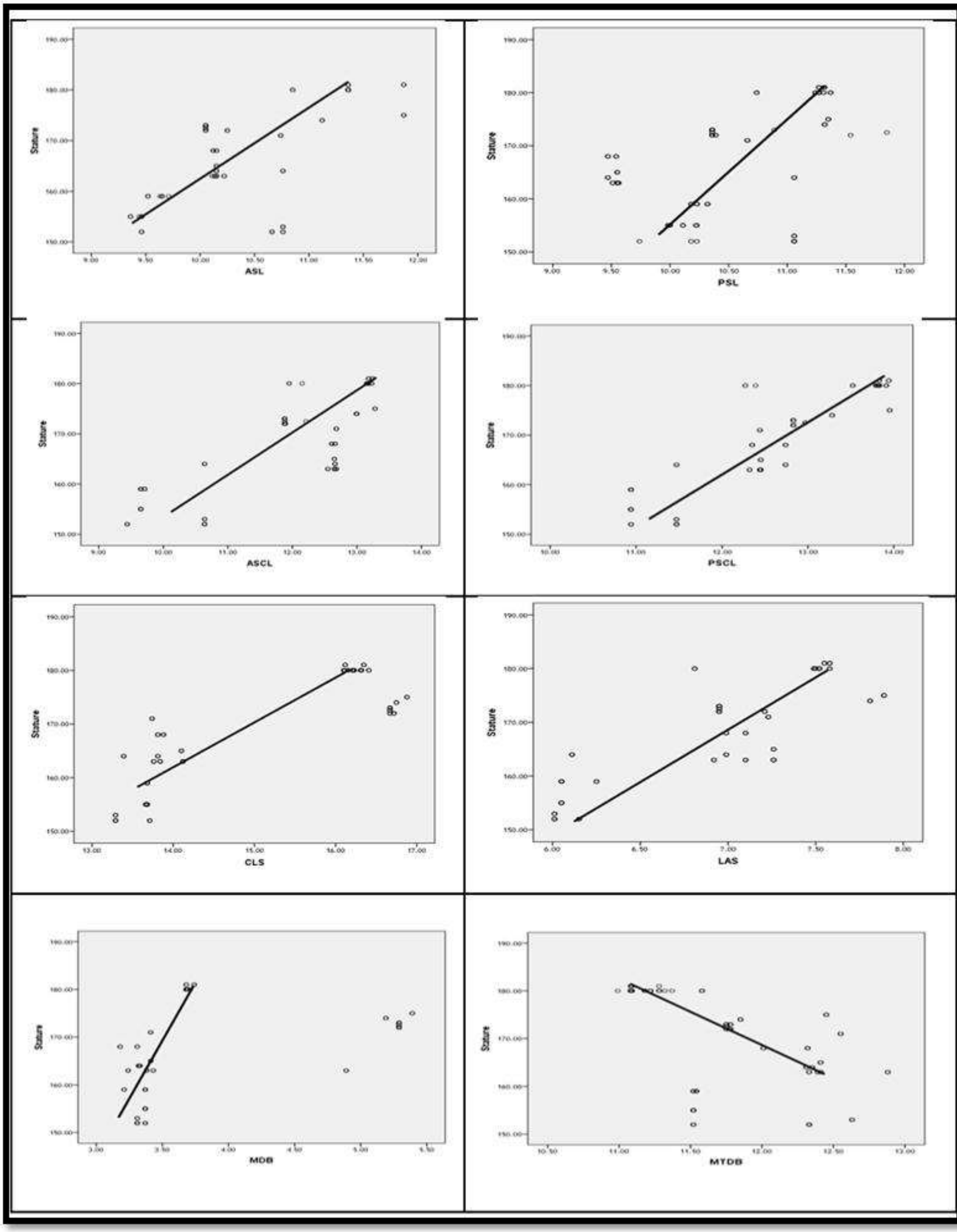

Figure1 :Scatter diagram showing Correlation between stature and CT parameters.

Table 2: Regression formula for CT parameters for stature determination between males and females:

	Male			Female		
	R^2	P	Predict formula	R^2	P	Predict formula
ASL	0.53	0.00**	63.8+(ASL*10.1)	0.49	0.00**	68.1+(ASL*8.9)
PSL	0.32	0.00**	87.6+(PSL*8.4)	0.26	0.00**	95.1+(PSL*6.9)
ASCL	0.68	0.00**	88.9+(ASCL*7.2)	0.64	0.00**	98.2+(ASCL*5.96)
PSCL	0.79	0.00**	57.6+(PSCL*8.9)	0.83	0.00**	61.3+(PSCL*8.1)
CLS	0.75	0.00**	71.6+(CLS*6.3)	0.69	0.00**	79.9+(CLS*5.2)
LAS	0.67	0.00**	64.8+(LAS*14.5)	0.78	0.00**	78.6+(LAS*12.8)
MDB	0.26	0.00**	144.9+(MDB*5.1)	0.21	0.00**	158.7+(MDB*3.9)
MTDB	0.32	0.00**	291.8(MTDB*-6.4)	0.24	0.00**	268.3(MTDB*-10.1)

**: very high significant (P value<0.001) P: Probability
R^2 :coefficient of determination

Table 3: Difference between actual stature and stature estimated by regression formula among males and females using paired –t-test:

		Mean	**SD**	**Paired t**	**P**
Male	Stature	173.3254	9.71488	0.512	0.741
	Estimated by ASL	173.6541	8.87456		
	Stature	173.3254	9.71488	1.124	0.214
	Estimated by PSL	173.8123	10.1245		
	Stature	173.3254	9.71488	0.112	0.811
	Estimated by ASCL	173.4121	7.65899		
	Stature	173.3254	9.71488	0.115	0.902
	Estimated by PSCL	173.2154	9.32146		
	Stature	173.3254	9.71488	0.652	0.515
	Estimated by CLS	173.5126	9.98745		
	Stature	173.3254	9.71488	0.541	0.589
	Estimated by LAS	173.6541	8.87456		
	Stature	173.7123	11.3254	0.312	0.708
	Estimated by MDB	173.6541	8.87456		
	Stature	173.3254	9.71488	0.698	0.512
	Estimated by MTDB	173.7123	10.5874		
Female	Stature	164.3214	10.2315	0.465	0.654
	Estimated by ASL	164.0121	9.25413		
	Stature	164.3214	10.2315	1.285	0.217
	Estimated by PSL	164.5124	11.2565		
	Stature	164.3214	10.2315	0.047	0.969
	Estimated by ASCL	164.1365	10.8974		
	Stature	164.3214	10.2315	0.318	0.811
	Estimated by PSCL	164.4125	12.3251		
	Stature	164.3214	10.2315	0.897	0.471
	Estimated by CLS	164.5286	11.8746		
	Stature	164.3214	10.2315	0.845	0.362
	Estimated by LAS	163.9874	10.8874		
	Stature	164.3214	10.2315	0.245	0.741
	Estimated by MDB	164.0898	9.99875		

	Stature	164.3214	10.2315	1.365	0.108
	Estimated by MTDB	164.6125	8.52146		

SD: standard deviation

2-Difference between actual stature and stature estimated by regression formula among male and female:

There was non statistical significant difference ($p<0.05$) founded between mean values of actual stature for males and females and the stature estimated using regression equations calculated from sacral and coccygeal CT measurementsThat proved success of regression formula. (Table.3).

DISCUSSION

Stature is one of the most important aspects of biological profile for an unknown individual in forensic anthropology (Ismail et al. 2018). Stature is positively correlated with long bone length.The most accurate stature estimation is obtained when undamaged long bones of known sex and ethnic identity are available (Akhlaghi et al.2016).However, it is not always possible to obtain intact long bones, especially in mass disasters (Saukko and Knight, 2016).

Stature estimation is normally calculated using the length of long bones, especially the lower limbs. Since the early 1980s, regression formulae have been calculated for estimating stature directly from other skeleton parts such as cranium, sternum, vertebrae, clavicle, scapula, sacrum, pelvis, hand and foot bones (Wiley, 2016).CT scanning has become a useful tool in forensic practice. Postmortem CT imaging is a good method to depict osseous structures. CT scans are used for typical forensic anthropological tasks such as sex and age determination (Thali et al. 2010).This study aimed to develop equations for estimating stature from measurements of the sacrum and coccyx by CT in Libyan population.

In the present study, stature was determined through the measurement of ASL, PSL, ASCL, PSCL, ASW, CLS, LAS, MDB and MTDB by using sacrum and coccyx CT. Pearson's correlation coefficient that assesses the correlation between the actual stature of subjects in study and CT parameters was measured. The stature of the living subjects was measured. This design reduces errors as measurement of bone lengths varies according to the methodology used. Dry bones are (approximately 2 mm) shorter than their fresh counterparts and require the application of corrective measures for regression equations. (Karakas et al.2011).

In the present study there was high statistically significant positive correlation between ASL, PSL, ASCL, PSCL, CLS, LAS, MDB and stature. There was high statistically significant negative correlation between MTDB and stature. There was non-significant correlation between ASW and stature in both males and females**.**Consistent with the results of the present study, Soon et al. (2020) founded positive correlation between the following parameter ASL, LAS, MDB and stature. Additionally, Karakas et al.(2011)founded positive correlation between ASL and stature.

In contrast withthe results of the present study, Soon et al. (2020) founded positive correlation between MTDBandstature.

An equation derived from a certain population will not be suitable for another originating from a differentiation. In addition, populations may experience secular variation, so the use of temporally representative skeletal collections is required for the derivation of anthropological standards (Ross et al. 2011).

In the present study, using simple linear regression equations, stature can be estimated from sacral and coccygeal parameters that were proven to be statistically high significant with highestR^2 which are PSCL , LAS, CLS,ASCL and ASL. Consistent with the results of the present study, Soon et al. (2020) founded that the most comparatively useful stature estimator is LAS. In contrast with the results of the present study Zhan et al.(2018) founded that MTDB gave the most accurate results for stature in males and females**.**

CONCLUSION

There was high statistically significant positive correlation between the ASL, PSL, ASCL, PSCL, CLS, LAS, MDB and stature while, there was high statistical significant negative correlation between MTDB and stature. Stature can be estimated from sacral and coccygeal parameters that were proven to be statistically significant with highest R^2 such as ASCL, PSCL, CLS and LAS. There was no statistical significant difference founded between mean values of actual stature and the stature estimated using regression equations that prove success of regression formula.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributes in all parts of paper.

Copyrights: © 2020@ author (s).

This is an open access article distributed under the terms of the **Creative Commons Attribution License (CC BY 4.0)**, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and source are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

REFERENCES

Akhlaghi, M.; Bakhtavar, K. andMoarefdoost, J. (2016):Frontal sinus parameters in computed tomography and sex determination.Journal of Legal medicine;1(19):22-27.

Benazzi, S.; Maestri, C. andParisini, S.; et al.(2009): Sex assessment from thesacral base by means of image processing. Journal of International Forensic Science;54(2): 249–254.

Cotter, M.M.; Whyms, B.J. and Kelly, M.P.; et al.(2015):Hyoid Bone Development: An Assessment of Optimal computed tomography Scanner Parameters and Three-Dimensional Volume Rendering Techniques. Journal of The Anatomical Record; 298(8):1408-1415.

D'Eyrames, G.E.;Siegmund, F. andPapageorgopoulou, C. (2009):Discriminant function analysis versus morphognostic sex determination of 637 crania from the Poschiavo ossuary. Bulletin of the Swiss Society for Anthropology; 15(1-2): 57-63.

Franklin, D.; Cardini, A.andFlavel, A.; et al.(2012): The application of traditional and geometric morphometric analyses for forensic quantification of sexual dimorphism: preliminary investigations in a Western Australian population. International journal of legal medicine;126(4):549-558.

Gómez-Valdés, JA.;Ramírez, GT. andMolgado, SB.; et al.(2011): Discriminant function analysis for sex assessment in pelvic girdle bones: sample from the contemporary Mexican population. Journal of forensic sciences.; 56(2):297-301.

IBM.C.R.(2017):IBM SPSSStatistics for Windows, Version Q3, 25.0. Armonk, NY: IBM Corp.

Ismail, N.A; AbdKhupur, N.H. and Osman, K.; et al.(2018):Stature estimation in Malaysian population from radiographic measurements of upper limbs. Egyptian Journal of Forensic Sciences; 8(1):22.

Kallalli, B.N.; Rawson, K. andRamaswamy, VK.; et al.(2016):Sex determination of human mandible using metrical parameters by computed tomography: A prospective radiographic short study. Journal of Indian Academy of Oral Medicine and Radiology;28(1):7-10.

Karakas, H. M.; Celbis, O. andHarma, A.; et al. (2011): Total body height estimation using sacrum height in Anatolian Caucasians: multidetector computed tomography-based virtual anthropometry. Journal of springer Skeletal radiology; 40(5): 623-630.

Karayol, S.S.; Karayol, K.C. and Dokumaci, D.Ş. (2019): Anatomic and morphometric evaluation of the coccyx in the adult population.Journal of Harran University Medical Faculty;16 (2):221-226.

Paulis, M. G. (2015). Estimation of stature from handprint dimensions in Egyptian population. Journal of forensic and legal medicine; 34: 55-61.

Pininski, M. and Brits, D.(2014):Estimating stature in South African populations using various measures of the sacrum. Journal of Forensic science international;1(234):1-13.

Ross, A. H.; Ubelaker, D. H. and Kimmerle, E. H. (2011): Implications of dimorphism, population variation, and secular change in estimating population affinity in the Iberian Peninsula.Journal of Forensic Science International;206(1-3): 1-5.

Saukko, P. and Knight, B. (2016): The establishment of identity of human remains, 4th ed., CRC Press, Chapter (3) pp: 95–132.

Soon, L. P.; Noor, M. H. M. and Abdullah, N.; et al.(2020): Stature estimation of the Malaysian population based on sacrum CT scans. Egyptian Journal of Forensic Sciences; 10(1): 1-11.

Standring,S. (2015): Gray's anatomy e-book: the anatomical basis of clinical practice,Back ,41th edition, Elsevier Health Sciences; chapter (43):726-750.

Thali, M.J.; Viner, M.D. and Brogdon, B.G. (2010): Brogdon's forensic radiology Book,2nd Edition. CRC Press; chapter(1-2): 3-12.

Torimitsu, S.; Makino, Y. andSaitoh, H.; et al.

(2014):Stature estimation in Japanese cadavers using the sacral and coccygeal length measured with multidetector computed tomography.Journal of Legal Medicine; 16(1):14-19.

Wiley, P. (2016): Stature estimation. In: Soren B, Douglas HU (eds) Handbook of forensic anthropology and archaeology, 2nd edition. Taylor & Francis, New York, USA.

Woon, J .T. and Stringer, M.D. (2012): Clinical anatomy of the coccyx: a systematic review. Journal of Clinical Anatomy;25(2):158–167.

Zhan, M. J.; Fan, F.andQiu, L. R.; et al. (2018): Estimation of stature and sex from sacrum and coccyx measurements by multidetector computed tomography in Chinese. Journal of Legal medicine;34: 21-26.

Zhang, Y.; Smitherman, C. and Samei, E. (2017):Size-specific optimization of CT protocols based on minimum detectability. Journal of international Medical physics; 44(4):1301-1311.