International Journal of
Medical Toxicology & Forensic Medicine
November 2017, Volume 7, Number 4

Research Paper: Using Subpubic Angle in Sex Determination and Stature Estimation: An Anthropometric Study on Iranian Adult Population

Mitra Akhlaghi[1,2], Khadijeh Bakhttavar[3], Tahmineh Mokhtari[4], Farzaneh Mehdizadeh[1], Vida Allahyar Parsa[1], Masoumeh Vasheghani Farahani[5], Maryam Vasheghani Farahani[6*], Mohammad Hossein Sadeghian[1]

1. Department of Forensic Medicine, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran.
2. Legal Medicine Research Center, Legal Medicine Organization, Tehran, Iran.
3. Department of Radiology, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran.
4. Department of Anatomy, School of Medicine, Tehran University of Medical sciences, Tehran, Iran.
5. Department of Internal Medicine, School of Medicine, Arak University of Medical Sciences, Arak, Iran.
6. Department of Forensic Medicine, Faculty of Medicine, AJA University of Medical Sciences, Tehran, Iran.

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Citation: Akhlaghi M, Bakhttavar Kh, Mokhtari T, Mehdizadeh F, Allahyar Parsa V, Vasheghani Farahani M, et al. Using Subpubic Angle in Sex Determination and Stature Estimation: An Anthropometric Study on Iranian Adult Population. International Journal of Medical Toxicology & Forensic Medicine. 2017; 7(4):195-202. http://dx.doi.org/10.22037/ijmtfm.v7i4(Autumn).17039

doi: http://dx.doi.org/10.22037/ijmtfm.v7i4(Autumn).17039

Article info:
Received: 13 Apr. 2017
Accepted: 07 Jul. 2017

Keywords:
Forensic anthropology, Pubic bone, Sex, Stature, Iranian population

ABSTRACT

Background: Pelvic bone has important sex determining features. However, anthropometric reference values vary by study population. This study aimed to determine the accuracy of subpubic angle for sex determination and height estimation in Iranian adults.

Methods: In this study, the subpubic angle in the digital pelvic radiographs of 325 Iranian adults (199 males and 126 females) and their standing heights were measured. Then, the relation of subpubic angle with sex and stature was evaluated.

Results: The mean(SD) subpubic angle of the studied population was 116.3 (23.7) degrees. Subpubic angle was significantly wider (P<0.001) in females [140.5(14.3) degrees] compared to males [101.0(13.3) degrees]. Moreover, we observed a significant decrease (P<0.001) in females' subpubic angle with an increase in age. A significant reverse correlation (P<0.01) was also observed between the subpubic angle and height (r=0.416).

Conclusion: This study showed that the mean subpubic angle in Iranian adults is different from the average in other populations. Our reference values can be used in forensic identification.

1. Introduction

Forensic human identification is often the first step in the process of victim identification following natural disasters, air crashes, murders, explosions and mass fatality events [1-3]. In these situations, remained body parts can be used for identification [4]. Since bones are the hardest and most durable structures of the body, they are commonly studied in forensic identification, sex determination and height estimation [5, 6]. The most important indexes are related to skull and pelvis with their

*** Corresponding Author:**
Maryam Vasheghani Farahani, MD
Address: *Department of Forensic Medicine, Faculty of Medicine, AJA University of Medical Sciences, Tehran, Iran.*
Tel: *+98 (21) 66566745*
E-mail: *vasheghani_m@yahoo.com*

important characteristics that makes them unique for sex determination [7]. Under the influence of genetics and environment, the body segments characteristics are different in various populations and also their dimensions can be used for predicting the stature or sex. The statistical equations can find these relations which have drawn the interest of scientist, artists, anthropologists, forensic medicine specialists and anatomists. In this regard, pelvis was the first topic of interest for many years [4].

Population-specific skeletal characteristics develop in societies that had been isolated over the course of history. Sex-specific features are inevitably clustered into these populations. Therefore, population- and sex-specific studies are indispensable. Sporadic repositories of human skeletal reference values exists but they are only a snapshot of population at an earlier time. Along with population migration and better access to means of transportation, populations had started to merge into each other. Therefore, the validity of reference values should be periodically tested, because they most probability have changed over time [8, 9].

Height can be formulated by the anthropological measurements from the body segments [10-13]. The sex detection was primarily performed by pelvic bone proportions [14-16]. Forensic practitioners need anthropological standards in their field of practice. These data can significantly contribute to studies on population movement, too. These data should be standardized for the study population, so that classification accuracy is assured [17, 18]. Pelvis has specific shape for its obstetrics functions and formation of the birth canal, therefore, it is very valuable in sex determination [19]. One of the pelvis parameters that is valuable in sex determination is the subpubic angle [20]. In the previous studies, conducted in United states [21, 22], England [23], Uganda [24], Malawi [25], South Africa [26], Egypt [27], and Nigeria [28, 29], significant differences in the subpubic angle between males and females have been reported with high accuracy for sex distinction. These studies also showed the difference of subpubic angle in various populations. This study was designed to determine the accuracy of subpubic angle for sex determination and height estimation in Iranian adult population.

2. Materials and Methods

Study sample

This cross-sectional study was performed from October 2013 to September 2014. A total of 325 anteroposterior (AP) pelvic radiographs of Iranian adults (more than 18 years) were selected by convenience sampling method and then evaluated for sex determination and stature estimation. All radiographs were prepared from Sina Hospital (affiliated to Tehran University of Medical Sciences, Tehran, Iran). In this study, only the subjects with radiographs of their pubic symphysis and inferior margin of the pubis with the suitable alignment were enrolled. The subjects with pelvic fractures, orthopedic surgeries, congenital malformations, known musculoskeletal abnormalities and general bone diseases such as rickets were excluded.

Measurements

Subpubic angle

Measurements were performed on standard digital AP pelvic radiographs (under standard conditions with a distance of 100 cm between the film and the X-ray source). The position of subjects was controlled during radiography by a trained technician according to standards. Two tangent lines were drawn on the inferior border of the pubic rami and a point was demarcated in the inferior and middle aspect of the interpubic disc (translucent areas in radiographs). The angle made through the intersection of these two lines on this point was measured by ISKPACS software (Figure 1). To reduce the measurement error, two experts did all measurements separately.

Stature measurement

Stature or standing height was also measured in standard position by accurate tape meter in cm. Standards position has been defined as a distance between vertex and floor when the subject is in standing barefooted position with looking forward eyes and head held in the Frankfurt horizontal plane [30].

Technical error of measurement

Technical Error of Measurement (TEM) was evaluated due to Dahlberg's formula (Equation 1). According to this equation, the measurements should be obtained twice in one week interval. In this equation, D is difference between the first and second measurements and the deviation between them and N is number of subjects.

Equation 1

$$\sqrt{\frac{\sum D^2}{2N}}$$

Statistical analysis

All data were analyzed by SPSS (version 22). Subjects were divided into three age groups, namely, 18-34, 35-

50 and above 50 years old. Descriptive data were shown as frequency, percentage frequency, mean, and standard deviation. For data analysis, ANOVA (with Tukey post hoc test) and t test were employed. The linear regression analysis method was used for stature estimation model and logistic regression modelling was used for sex determination model. The cut-off point with the sensitivity and specificity was defined for each age group. P-values less than 0.05 were considered as significant level.

3. Results

In this study, 325 AP radiographs of Iranian adults belonging to 126(38.76%) women and 199(61.23%) men were studied. Their mean(SD) age was 44.27(22.83) years. Subjects were divided into three age groups of 18-34, 35-50 and ≥51 years old. Mean(SD) subpubic angle in the studied population was 116.3(23.7) degrees and TEM was 0.0031 according to Dahlberg Equation. Mean(SD) subpubic angle was 101.0(13.3) degrees in males and 140.5(14.3) degrees in females and there was a significant difference in the subpubic angle of sex groups (P<0.001) (Table 1). In addition, according to Table 2, there were significant differences in the subpubic angle between the sexes in each age group.

Power of subpubic angle for sex determination in the whole population and each age group was evaluated (Table 3). According to Table 4, the cut-off points of subpubic angle were defined for all subjects and age groups. The subpubic angle of 117.4 degrees (with accuracy of 87.2%) was estimated as a cut-off point of for sex determination in the studied population. In the 18-34, 35-50 and above 50 age groups, the cut-off points of 119.7 degrees (with the accuracy of 86.3%, Table 3), 113.7 degrees (with the accuracy of 86.4%, Table 3) and 114.9 degrees (with the accuracy of 68.8%, Table 3) were estimated, respectively.

Using the logistic regression test, the following formula was generated to predict the sex by subpubic angle:

Sex=(Subpubic angle in degrees×0.017)–1.568

If the yielded number is below 0.5, the sex is male and if it is equal or above 0.5 the sex is female (accuracy=82%). The mean value of the subpubic angle between age groups was not significantly different in the whole group (P=0.489). Likewise, there was no significant difference in the subpubic angle measurements in males' age groups (P=0.18) but this difference was significant in females' age groups (P<0.001), which means that the subpubic angle was lower in the elder groups (Table 4).

Using the linear regression test, a significant reverse correlation was found between the subpubic angle and the height (r=0.416, P<0.01). This relation was observed in 18-34, 35-50 and above 50 years age groups with 0.435, 0.44 and 0.373 correlation coefficients, respectively. The best correlation between stature and subpubic angle was observed in the 35-50 age group. In the whole group, the following formula was calculated for stature estimation (R^2=0.42):

Stature(cm)=[Subpubic angle in degrees× (-0.172)] + 188.601

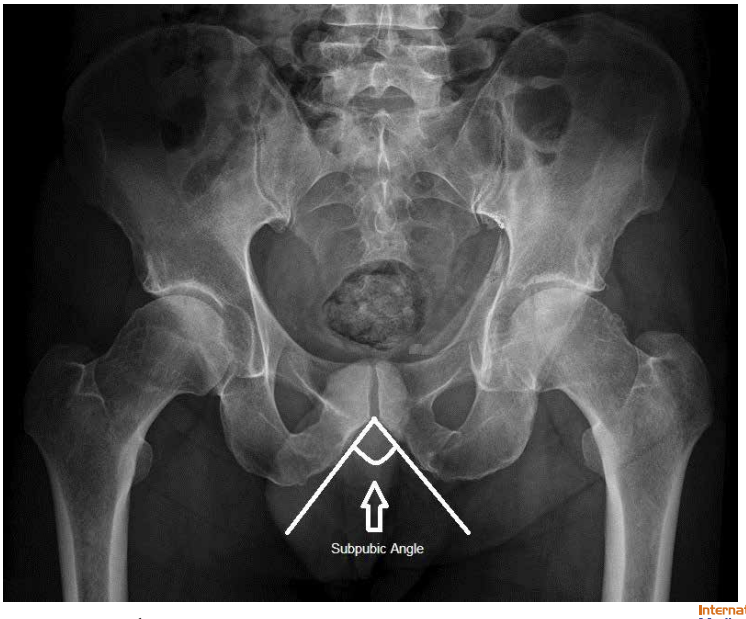

Figure 1: Subpubic angle measurement

Table 1. Mean, standard deviation, standard error, maximum and minimum of the subpubic angle in the studied population

Sex	Age Groups, y	Mean (Degree)	SD	SE	Minimum	Maximum	95% CI	P
Male	18-34	101.8	14.2	1.38	55.4	140.6	99-104.5	0.18
	35-50	98.1	12.3	1.7	73.6	127.7	94.7-101.5	
	≥51	102.7	11.8	1.86	77.5	136	98.9-106.4	
	Total	101.0	13.3	0.94	55.4	140.6	99.1-102.8	
Female	18-34	147.2	11.0	1.67	117.7	160.7	143.8-150.6	0.0001
	35-50	143.5	12.3	2.00	103.2	167.7	139.5-147.5	
	≥51	132	14.6	1.16	101.5	160.3	127.6-136.3	
	Total	140.5	14.3	1.28	101.5	167.7	138.0-143.1	

SD: Standard Deviation; SE: Standard Error; CI: Confidence Interval

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4. Discussion

In the present study, subpubic angle was measured in Iranian population and its differences between sex groups and age groups were evaluated. In addition, stature and sex were formulated according to the pubic angle in Iranian population. The mean subpubic angle in Iranian population was 116.3 degrees. This result was almost similar to the reported subpubic angle in Msamati et al. [25] and Oladipo et al. studies [29, 31]. However, the obtained subpubic angle in Iranian population was different from Ugandan, American, South Africans, British, Egyptian, and African studies [24, 26, 29]. Since the study design and measurements were similar, this difference could be due to ethnic, geographical and regional differences (Table 5).

Table 2. Comparison of mean, standard deviation, standard error, maximum and minimum of the subpubic angle in each age group and sex

Age Groups (n)	Sex	Mean (Degree)	SD	SE	Minimum	Maximum	95% CI	P
18-34 (126)	Male	101.8	14.2	1.38	55.4	140.6	99.0-104.5	<0.001
	Female	147.2	11.0	1.69	117.7	160.7	143.8-150.6	
	Total	114.7	24.5	2.01	55.4	160.7	110.7-118.7	
35-50 (102)	Male	98.1	12.3	1.69	73.6	127.7	94.7-101.5	<0.001
	Female	143.5	12.3	1.99	103.2	167.7	139.5-147.5	
	Total	117.1	25.6	2.68	73.6	167.7	111.7-122.4	
>50 (97)	Male	102.7	11.8	1.86	77.5	136.0	98.9-106.4	<0.001
	Female	132.0	14.6	2.16	101.5	160.3	127.6-136.3	
	Total	118.3	19.8	2.14	77.5	160.3	114.1-122.6	
Total (325)	Male	101.0	13.2	0.94	55.4	140.6	99.1-102.8	<0.001
	Female	140.5	14.3	1.28	101.5	167.7	138.0-143.1	
	Total	116.3	23.7	1.31	55.4	167.7	113.7-118.9	

SD: Standard Deviation; SE: Standard Error; CI: Confidence Interval

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Table 3. Discrimination power of subpubic angle in each age group

Age Group, y	Area	SEM	P	95% CI
18-34	0.993	0.005	<0.001	0.984-1.002
35-50	0.990	0.010	<0.001	0.970-1.009
Above 50	0.940	0.024	<0.001	0.892-0.987
Total	0.972	0.008	<0.001	0.956-0.988

SEM: Standard Error; CI: Confidence Interval

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The mean subpubic angle in male subjects was 101.0 degrees that was similar to the findings of Msamati et al. [25], Oladipo et al. [31] and Abd-el-Hameed et al. [27] results. The mean of subpubic angle in females was 140.5 degrees similar to Abd-el-Hameed et al. results [27]. This could also be due to ethnic, regional, geographical and age-related differences (Table 5).

As previous studies have shown, there were significant differences between populations and even ethnicities of black population but evidently the subpubic angle is wider in black males and females [24, 29, 31]. Interestingly, the subpubic angle in South African black population is smaller compared to other black populations [26].

According to the results, subpubic angle could predict the sex in Iranian population and its accuracy was high. Based on previous studies, the subpubic angle was found to be different between two sex groups. The accuracy of subpubic angle in sex determination varies in different studies [24-29]. This could be due to racial differences or the methods of analysis. In the present study, the accuracy of the subpubic angle was found to be 87%, which could be favorably used in forensic identification (Table 5).

Karakas et al. (2013) could find a correlation of 0.99 between subpubic angle and sex. The study was conduct on 66 male and 43 female of Anatolian Caucasians. The reported accuracy was higher than 90% in this study. These investigators had a sensitivity of 88% and a specificity of 95% to detect female phenotype [32].

A very recent study on West Australian population found that both transverse pelvic outlet and subpubic angle can be accurately used in sex discrimination. These researchers found an accuracy rate ranging from 81.2% for ischial length to 100% for the complete pelvis. Although this is the first report on the Western Australian population, authors found that the pelvic bone can accurately discriminate sex in this population [33].

In addition, a significant difference was observed in female age groups. In females, the angle decreased significantly with an increase in age. In addition, Nwoha [34] and Oladipo et al. [29] reported this relation in their studies that is probably due to racial, nutritional and life-style differences. This result should be more investigated in future. Also, the accuracy of subpubic angel for sex determination decreases with an increase in age, which should be notified in practice. According to the literature, the relation between stature and subpubic angle has not been investigated yet and should be considered in other populations.

5. Conclusion

Based on the results, there was a significant relationship between subpubic angle and sex in Iranian

Table 4. Demarking point, sensitivity, specificity and accuracy in the studied population and each age group

Age Group, y	Cut-Off Point (Degree)	Sensitivity (%)	Specificity (%)	Accuracy (%)
18-34	119.65	98.2	89.1	86.3
35-50	113.65	97.2	89.6	86.4
Above 50	114.85	85.7	87.5	68.8
Total	117.40	93.5	89.4	87.2

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Table 5. Comparison of subpubic angle in each sex in different studies

Authors, Date	Country, Population	Mean±SD of SPA (Degree)		Mean (Degree)	Males		Females	
		Males	Females		COP (Degree)	Accuracy	COP (Degree)	Accuracy
[22]	USA (Caucasian)	<60	>90					
[23]	England (Caucasians)	75.8±5.80	93.5±7.4					
[35]	American (Indigene American)	67.4±8.10	93.1±10.4	80.25				
	White American	63.7±7.80	88.4±8.5	76.05				
	African American	65.8±8.70	85.2±8.5	98.21				
[24]	Ugandans Black	93.86±11.12	116.11±17.79	104.98	<80.53	31.82	>136.10	10.53
[25]	Malawians Black	99.16±15.73	129.07±14.19	98.21	<99.95	67.12	>130.62	63.02
[29]	Nigerians Black	91.87±10.60	113.49±11.38	103.80	<92.33	56.57	>113.07	53.47
[28]	Ijaws African	109.38±10	119.48±12.06	103.36	<95.36	78.95	>129.38	14.52
	Igbos African	95.29±10.52	114.41±12.06	114.43	<85.74	26.67	>116.04	52.73
[27]	Egyptians African	102.31±12.5	143.28±15.82	122.79	<111.64	74	>127.31	86.5
[31]	Ikwerres African	100.25±7.80	119.38±3	115.31				
	Kalabaris African	105.63±3.88	125±3.17	109.82				
[26]	White South Africans	70.67±9.35	93.86±11.15		<81.4	86	>81.4	88
	Black South Africans	63.9±11.08	84.1±8.90		<74.87	86	>74.78	84
[32]	Anatolian Caucasians	65.9±7.2	82.8±7.7	72.5	<74	95.5	>74	83.7
Present Study	Iranian (Persians)	101.0±13.3	140.5±14.3	116.31	<117.4	87	>117.4	87

COP: Cut-Off Point; SPA: Subpubic Angle.

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population. Also, the subpubic angle accuracy was high in predicting the sex in Iranian population. Moreover, a significant reverse correlation was found between the subpubic angle and height. However, the reliability was in moderate level and can be helpful in stature estimation along with other parameters. In sum, subpubic angle could be favorably used in sex determination of Iranian adult population. Further studies are required to address the variations in different populations.

Acknowledgements

This research was extracted from the MD thesis of Tahmineh Mokhtari, in Department of anatomy, Tehran University of Medical Sciences; and did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

All authors certify that this manuscript has neither been published in whole nor in part nor being considered for publication elsewhere. The authors have no conflicts of interest to declare.

References

[1] Holobinko A. Forensic human identification in the United States and Canada: A review of the law, admissible tech-

niques, and the legal implications of their application in forensic cases. Forensic Science International. 2012; 222(1):394. doi: 10.1016/j.forsciint.2012.06.001

[2] Lake A, James H, Berketa J. Disaster victim identification: quality management from an odontology perspective. Forensic Science, Medicine, and Pathology. 2012; 8(2):157-63. doi: 10.1007/s12024-011-9286-x

[3] Schuliar Y, Knudsen PJT. Role of forensic pathologists in mass disasters. Forensic Science, Medicine, and Pathology. 2012; 8(2):164-73. doi: 10.1007/s12024-011-9300-3

[4] Shah T, Patel M, Nath S, Menon SK. A model for construction of height and sex from shoulder width, arm length and foot length by regression method. Journal of Forensic Science & Criminology. 2015; 3(1):102. doi: 10.15744/2348-9804.2.402

[5] Akhlaghi M, Moradi B, Hajibeygi M. Sex determination using anthropometric dimensions of the clavicle in Iranian population. Journal of Forensic and Legal Medicine. 2012; 19(7):381-5. doi: doi: 10.1016/j.jflm.2012.02.016

[6] Akhlaghi M, Sheikhazadi A, Naghsh A, Dorvashi G. Identification of sex in Iranian population using patella dimensions. Journal of Forensic and Legal Medicine. 2010; 17(3):150-5. doi: doi: 10.1016/j.jflm.2009.11.005

[7] Rösing F, Graw M, Marré B, Ritz-Timme S, Rothschild M, Rötzscher K, et al. Recommendations for the forensic diagnosis of sex and age from skeletons. HOMO-Journal of Comparative Human Biology. 2007; 58(1):75-89. doi: 10.1016/j.jchb.2005.07.002

[8] Franklin D, Freedman L, Milne N. Sexual dimorphism and discriminant function sexing in indigenous South African crania. HOMO-Journal of Comparative Human Biology. 2005; 55(3):213-28. doi: 10.1016/j.jchb.2004.08.001

[9] Franklin D, Cardini A, Oxnard CE. A geometric morphometric approach to the quantification of population variation in sub-Saharan African crania. American Journal of Human Biology. 2010; 22(1):23-35. doi: 10.1002/ajhb.20908

[10] Ragavan S, Chandran M. Stature estimation from hand length and foot length in adults-a regional study in Chennai, Tamilnadu. Indian Journal of Forensic Medicine & Toxicology. 2015; 9(1):205-11. doi: 10.5958/0973-9130.2015.00050.x

[11] Uhrová P, Beňuš R, Masnicová S, Obertová Z, Kramárová D, Kyselicová K, et al. Estimation of stature using hand and foot dimensions in Slovak adults. Legal Medicine. 2015; 17(2):92-7. doi: 10.1016/j.legalmed.2014.10.005

[12] Khan HBMA, Nataraja Moorthy T. Stature estimation from the anthropometric measurements of footprints among Melanaus: An indigenous population of Malaysian Borneo. Canadian Society of Forensic Science Journal. 2015; 48(2):68-84. doi: 10.1080/00085030.2015.1019225

[13] Krishan K, Kanchan T, Sharma A. Multiplication factor versus regression analysis in stature estimation from hand and foot dimensions. Journal of Forensic and Legal Medicine. 2012; 19(4):211-4. doi: 10.1016/j.jflm.2011.12.024

[14] Sutherland LD, Suchey JM. Use of the ventral arc in pubic sex determination. Journal of Forensic Sciences. 1991; 36(2):501-11. doi: 10.1520/jfs13051j

[15] Schulter-Ellis F, Schmidt D, Hayek L, Craig J. Determination of sex with a discriminant analysis of new pelvic bone measurements: Part I. Journal of Forensic Sciences. 1983; 28(1):169-80. doi: 10.1520/jfs12249j

[16] Singh S, Potturi BR. Greater sciatic notch in sex determination. Journal of Anatomy. 1978; 125(3):619. PMCID: PMC1235628

[17] Ross A, Ubelaker D, Kimmerle E. Implications of dimorphism, population variation, and secular change in estimating population affinity in the Iberian Peninsula. Forensic Science International. 2011; 206(1):214. doi: 10.1016/j.forsciint.2011.01.003

[18] Steyn M, İşcan M. Metric sex determination from the pelvis in modern Greeks. Forensic science international. 2008; 179(1):86. doi: 10.1016/j.forsciint.2008.04.022

[19] Abitbol MM. The shapes of the female pelvis. Contributing factors. Journal of Reproductive Medicine. 1996; 41(4):242-50. PMID: 8728076

[20] Luo YC. Sex determination from the pubis by discriminant function analysis. Forensic Science International. 1995; 74(1):89-98. doi: 10.1016/0379-0738(95)01739-6

[21] Washburn SL. Sex differences in the pubic bone. American Journal of Physical Anthropology. 1948; 6(2):199-208. doi: 10.1002/ajpa.1330060210

[22] Caldwell W, Moloy H. Anatomical variations in the female pelvis: Their classification and obstetrical significance. Proceedings of the Royal Society of Medicine. 1938; 32(1):1. doi: 10.1148/48.5.527

[23] Young M, Ince JH. A radiographic comparison of the male and female pelvis. Journal of Anatomy. 1940; 74(3):374. PMCID: PMC1252596

[24] Igbigbi PS, Nanono-Igbigbi AM. Determination of sex and race from the subpubic angle in Ugandan subjects. American Journal of Forensic Medicine and Pathology. 2003; 24(2):168-72. doi: 10.1097/01.paf.0000065149.42423.85

[25] Msamati B, Igbigbi P, Manda J. The sub-public angle in adult indigenous Malawian subjects. East African Medical Journal. 2005; 82(12):643. doi: 10.4314/eamj.v82i12.9370

[26] Small C, Brits DM, Hemingway J. Quantification of the subpubic angle in South Africans. Forensic Science International. 2012; 222(1):395. doi: 10.1016/j.forsciint.2012.06.002

[27] Abd-El-hameed SY, Mohamed AA, Thabet HZ. Determination of subpubic angle in Egyptian Population. Journal of Forensic Medicine and Clinical Toxicology. 2009; 17(1):41-53.

[28] Oladipo G, Ugboma H, Suleiman Y. Comparative Study of the Sub-pubic Angles of Adult Ijaws and Igbos. Asian Journal of Medical Sciences. 2009; 1(2):26-9.

[29] Oladipo G. The subpubic angle in adult indigenous Nigerians. Tropical Journal of Medical Research. 2007; 10(1):15-9. doi: 10.4314/tjmr.v10i1.30459

[30] Moorthy TN, Mostapa AMB, Boominathan R, Raman N. Stature estimation from footprint measurements in Indian Tamils by regression analysis. Egyptian Journal of Forensic Sciences. 2014; 4(1):7-16. doi: 10.1016/j.ejfs.2013.10.002

[31] Oladipo G, Okoh P, Hart J. Comparative study of the subpubic angles of adult Ikwerres and Kalabaris. Asian Journal of Medical Sciences. 2010; 2(107):10.

[32] Karakas HM, Harma A, Alicioglu B. The subpubic angle in sex determination: Anthropometric measurements and analyses on Anatolian Caucasians using multidetector computed tomography datasets. Journal of Forensic and Legal Medicine. 2013; 20(8):1004-9. doi: 10.1016/j.jflm.2013.08.013

[33] Franklin D, Cardini A, Flavel A, Marks MK. Morphometric analysis of pelvic sexual dimorphism in a contemporary Western Australian population. International Journal of Legal Medicine. 2014; 128(5):861-72. doi: 10.1007/s00414-014-0999-8

[34] Nwoha PU. The anterior dimensions of the pelvis in sex determination. West African Journal of Medicine and Medical Science. 1992;24(4):329-35.

[35] Tague RG. Variation in pelvic size between males and females. American Journal of Physical Anthropology. 1989; 80(1):59-71. doi: 10.1002/ajpa.1330800108