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Sex estimation by femur in modern Thai population

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Abstract

Sex estimation is an important step of postmortem investigation and the femur is a useful bone for sex estimation by using metric analysis method. Even though there have been a reported sex estimation method by using femur in Thais, the temporal change related to time and anthropological data need to be renewed. Thus the aim of this study is to re-evaluate sex estimation by femur in Thais. 97 adult male and 103 female femora were random chosen from Forensic osteology research center and 6 measurements were applied tend to. To compare with previous Thai data, mid shaft diameter to increase but femoral head and epicondylar breadth to stabilize and when tested previous discriminant function by vertical head diameter and epicondalar breadth, the accuracy of prediction was lower than previous report. From the new data, epicondalar breadth is the best variable for distinguishing male and female at 88.7 percent of accuracy, following by transverse and vertical head diameter at 86.7 percent and femoral neck diameter at 81.7 percent of accuracy. Multivariate discriminant analysis indicated transverse head diameter and epicondylar breadth performed highest rate of accuracy at 89.7 percent. The percent of accuracy of femur was close to previous reported sex estimation by talus and calcaneus in Thai population. Thus, for especially in case of lower limb remain, which absence of pelvis. ***Clin Ter 2017; 168(3):e203-207. doi: 10.7417/CT.2017.2007***

Key words: *Femur, age, estimation, stature, osteology, study*

Introduction

Sex estimation is an important step of postmortem investigation and the correct sex determination is crucial in developing biological profile and further analysis, such as age and stature estimation which is related to sex(1). In fresh or non-severely decomposed deceased sex is not difficult to determine but in the case where skeletal remains are incomplete, burned and severely decomposed, sex estimation from bone is necessary. Method of sex estimation is divided into metric and non-metric methods. The the former is more objective but morphologic analysis of pelvis is the most accurate method.

Although the pelvic bone is the best determinant sexes but in forensic context pelvic bone may not present or may not be well preserved thus other bone is needed for sex determination .The second most accurate method is metric analysis of various long bones (2). Femur is one suitable bone to determine sex by metric method due to difference in size and robustness but less in morphologic difference of males and females. Moreover, it is frequently found at the scene and better preserved than other long bone (3).

There were several studies of sex estimation by femur and different region dimension of femur illustrates an interesting result. Proximal and distal femur has been proved useful for sex estimation because these areas are related to weight bearing and muscle attachment. Previous study of Bosnian (4), Croatian (5), French (6), Spanish (7, 8), South African (9) and Japanese (10) femoral head diameter or epicondylar breadth can predict sexing with more than 90 percent of accuracy. While femoral neck diameter is one alternative variable for sex estimation due to well preservation, and lack of evidence of changes related to age (7). Studies of sex estimation by using FND achieved 91.9 percent of accuracy in Spanish (7) and approximately 90 percent in Euro-American, and African-American from the Hamann-Todd collection (11). While mid shaft diameter was a less in prediction in sexes than proximal and distal femur in most of the population (5, 12-14).

Despite the fact that the femur can give a high percentage of accuracy of sex estimation in many studies, due to inter population variety , the result of one population usually cannot be applied to other populations. Previous study of Thai population by King et al (14)reported sex estimation method by using femoral head diameter, femur range, mid –shaft circumference, AP and transverse diameter of midshaft and epicondylar breadth , VHD and epicondylar breadth were the best combination variables for sex estimation. However due to small sample sizes (114 samples) which cut this off 34 female samples and due to temporal change related to time anthropological data. Moreover there was no report of sex estimation by using Transverse head diameter (THD) and femoral neck diameter (FND) in the Thai population before. Therefore the aim of this study is to re-evaluate sex

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estimation by femur in the Thai population by using simple and practical forensic context measurement method of femur and to also study the THD and FND for cut this off sex estimation in Thai population.

Material and Method

Material

92 adult male and 103 female femora were random chosen from Forensic osteology research center. All samples were preserved in plastic boxes and information and data derived from of document of deceased who who died died since 2003 to 2014. All skeleton have document of sex, age at death, ancestry, stature, cause of death and profession. Age range of samples were 22-94 years, mean age of male samples was 65 years and female sample was 66 years. Severe degenerative change, fracture of femora, and prostheses replacement of samples were excluded.

Measurement

Six measurements consisting of Vertical head diameter (VHD), Transverse head diameter (THD), Femoral neck diameter (FND), Mid shaft transverse and antero-posterior diameter (Mid-AP, Mid-Tran), and Epicondylar breadth (EB) were taken to the nearest 0.01 mm using digital sliding calipers (detail of each measurement were defined in table 1). Left side of femur was measured twice, consecutively, by the same author, and 32 random samples were measured again by another author.

Data analysis

VHD and EB were used to test sex estimation equation and demarking point of previous report in Thai population.

Measurement errors were assessed by technical error of measurement (TEM) and coefficient of reliability (R). Descriptive statistics were obtained for each dimension and independent t-test was used to access sexual dimorphism of each dimension. Variables that show significant difference between male and female were conducted to discriminant function analysis. Normality of each variable was tested by Kolmogorov-Smirnov statistic. Selected variable were computed by direct and stepwise discriminant function analyses to find the best single or combination variable for estimating the sexes. For the stepwise method, all selected variables were entered into a stepwise discriminant function procedure using Wilks' lambda, to define which variable provided the best discrimination between male and female groups. Significant statistics significant were observed at value below0.05 and all data were analyzed by SPSS v 20.

Result

Measurement errors of each variable were shown in Table 2. For intra observation errors all variables indicate low technical error of measurement (TEM) 0.10-0.19 mm and high value of R 0.99 while inter-observation error Mid transverse diameter was the lowest TEM (0.22) and EB was the highest TEM (0.49), however all variables showed high value of R 0.97-0.99.

Descriptive statistics shown in Table 3, Mean value variable of the male was significantly higher than female significantly and all variables were found in a normal distribution. Compared with previous Thais data, mid-shaft diameter trend increase, while VHD and EB trend stabilize.

All samples of this study were subject to test of the demarking point and discriminant function of previous reported, result shown in table 4. The percentage of accuracy of discriminant function by using VHD and EB was lower than the previous report 4.5 percent.

Discriminant function analysis was applied to samples, coefficient of function and percentage of accuracy for male and female were calculated and shown in table 5. Each equation require coefficient and constant of the function to calculate score, and if score was more than zero the sample was classified as male whereas if score was less than zero, the sample was classified as female. For single variable, EB is the best variable for discriminant between male and female (88.8 %) followed by VHD and THD at 86.7 percent

Table 1. Measurement of variables on femur

	Variable	Description	Source
1	Vertical head diameter (VHD)	maximum diameter of the femoral diameter vertically: was taken with the anterior part of the femur facing the observer, and the arms of the caliper in the same direction as the neck, both condyles against the vertical surface of a board, with the head of the femur facing the observer	(6)
2	Transverse head diameter (THD)	maximum diameter of the femoral diameter horizontally : THD was taken by setting the diaphysis of the femur vertically and the arms of the caliper horizontally, with the head of the femur facing the observer	(6)
3	Femoral neck diameter (FND)	Supero-inferior femoral neck diameter, minimum) The minimum diameter of the femoral neck taken in a supero-inferior direction across the narrowest part of the femoral neck	(15)
4	Midshaft antero-posterior diameter (Mid-AP)	antero-posterior dimension of mid shaft	(16)
5	Midshaft transverse diameter (Mid –tran)	transverse dimension at the midshaft	(16)
6	Epicondylar breadth (EB)	maximum width between the epicondyles	(16)

Table 2. Intra and inter observer error statistics for femora measurement

Measure	Intra-observer error						Inter-observer error					
	N	Median Abs Different (mm)	Mean Abs Different(mm)	Technical Error of Measurement (mm)	R	Mean Difference as Percentage of Mean Size (%)	N	Median Abs Different (mm)	Mean Abs Different (mm)	Technical Error of Measurement (mm)	R	Mean Difference as Percentage of Mean Size (%)
VHD	195	0.10	0.12	0.13	0.99	0.20	32	0.018	0.12	0.24	0.99	0.28
THD	195	0.11	0.12	0.10	0.99	0.29	32	0.030	0.10	0.23	0.99	0.23
FND	195	0.11	0.13	0.14	0.99	0.36	32	0.31	0.36	0.42	0.97	1.2
Mid AP	195	0.11	0.13	0.12	0.99	0.40	32	0.23	0.49	0.49	0.97	1.7
Mid Tran	195	0.10	0.13	0.19	0.99	0.51	32	0.06	0.10	0.22	0.99	0.3
EB	195	0.11	0.12	0.11	0.99	0.14	32	0.2	0.71	0.59	0.99	0.9

Table 3. Descriptive statistic of variable compared between Male and Female and previous Thai data

Variable	Male				Female				Mean Difference	T	P value
	Min-Max	Mean	SD	Mean (King)	Min-Max	Mean	SD	Mean (King)			
VHD	39.6-50.38	45.05	2.30	45.1	26.55-45.30	39.47	2.76	39.3	5.58	15.2	<0.01
THD	39.92-50.35	44.15	2.27	-	30.50-44.80	39.31	2.46	-	5.31	15.6	<0.01
FND	27.07-36.94	31.94	2.34	-	25.92-35.85	27.93	2.14	-	4.01	12.49	<0.01
Mid- AP	24.48-35.12	29.26	2.33	27.8	20.19-32.70	25.72	2.34	24.7	3.53	10.52	<0.01
Mid-Trans	21.40-29.57	26.07	1.61	25.3	18.46-29.65	24.06	2.16	23.3	2.01	7.4	<0.01
EB	71.53-88.84	79.86	4.0	79.7	60.86-79.71	70.71	3.43	70.0	9.08	17.04	<0.01

Table 4. Accuracy percentage by previous Thai discriminant function

Variable	Function/Demarking point	Percent of accuracy		
		Male	Female	Total
VHD	Female<42.18<Male	90.2	84.5	87.2
EB	Female<79.55<Male	85.9	89.3	87.7
VHD and Bi-Epi	0.3229101(VHD) +0.1298626(Bi-Epi) -23.86411 = DS DS >-052985 = Male	90.2	89.3	89.7

Table 5. Direct and Stepwise Discriminant Model and Percent of Accuracy

Function	**Variable**	**Coefficient**	**Group centroid**	**% Cross validation**		
				Male	Female	Total
1	VHD Constant	0.391 -16.45	M 1.152 F -1.029	88	85.4	86.7
2	THD Constant	0.42 -17.62	M 1.183 F -1.057	88	85.4	86.7
3	FND Constant	0.447 -13.335	M 0.947 F -0.846	79.3	83.5	81.5
4	Mid- AP Constant	0.427 -11.696	M 0.797 F -0.712	77.2	78.6	77.9
5	Mid-Trans Constant	0.519 -12.974	M -0.55 F -0.493	71.7	69.9	70.8
6	EB Constant	0.269 -20.21	M 1.292 F -1.15	84.8	92.3	88.7
7	THD EB Constant	0.179 0.179 -20.913	M 1.3 F -1.2	88	91.3	89.7
8	THD FND Constant	0.344 0.114 -17.765	M 1.26 F-1.07	84.8	84.5	84.6

and FND at about 81 percent. On the other hand, mid part of femur both Midshaft AP and transverse can determinant male and female only 70.8 and 77.9 % of the cases.

Stepwise procedure variables were divided into 2 groups, the first group was all variable and second group was variable of proximal femur (VHD, THD and FND).For first group THD and EB were selected to function and the combination of THD and EB improved the accuracy of data to 89.7% while the second group THD and FND, the percentage of accuracy was not improved.

Discussion

Femurs have been extensively studied for sex estimation and it was proved suitable for metric analysis method. Intra and inter observation error illustrate low TEM and high an R value, R value of all variable were greater than 0.75 which is acceptable (17). This result supports VHD and THD measurement methods of Alunni et al that is repeatable and reproducible.

There were several studies reporting different sizes of femoral head and epicondylar breadth, Asian is relatively smaller than European and Africa. Among Asian sizes VHD and THD in the present study were larger than North Indian(18)and Chinese (19) but smaller than Japanese(10) and in present study VHD was relatively larger than THD, which contrasts cut this off North Indian (18), Chinese (14) and Japanese (10). While the size epicondylar breadth in this study was relatively larger than North Indian (18) and Japanese (10) but smaller than Chinese (14). Data of femoral neck diameter in Thai population has not been reported and compared to other populations, FND in this study was relatively smaller than Spanish (7) French (15), and American (11, 20)but larger than North Indian(18) and Guatemalian (21).

In the present study, all variables indicating dimensions of male have been larger significantly than female. When compared with previous report mid shaft diameter tend to increase, these findings may be due to the changing of nutrition and environment in the modern Thai population which affects the growth of bone (2, 22). Even through proximal and epiphyseal end of the femur to stabilize, discriminant function of previous study were tested by samples in this study, which showed a lower percentage of accuracy previous report. The reason for this may be due to the small amount of female samples in previous study caused less variation of samples.

In this study epicondylar breadth is the best variable for sex prediction. This finding is similar to studies of North Indian (18), Chinese (14) and South African (9), but the rate of accuracy was lower than 90 percent. This result was similar to studies in North Indian (18) and Germans (12). Despite the femoral head diameter having a lower ability to determine sexes than epicondylar breadth in this study but studies in Croatian (4) and German (12) population, femoral head diameter indicted a higher ability of sex estimation than epicondylar breadth. VHD was a common measurement for sex estimation and some studies considered that the accuracy obtained from the VHD was better than that obtained from the THD (6, 10). However, studies in German (12) and Spanish (8) report the difference result. While in present study VHD and THD perform the same ability of predicting sexes.

Femoral neck diameter is an alternative dimension of femur for sex estimation but has not been reported in the Thai population, which previous studies in Spanish and American populations, FND can use to determine sex with approximately 90 percent accuracy (7, 20). On the other hand the rate of accuracy by using FND in this study was only 81.5 percent. This result indicates less difference of FND between male and female in the Thai population, but it will be a benefit in the case where the fragment of femur which the head and distal end were not preserved.

Mid shaft diameter, both AP and transverse, illustrated a lower ability to predict sexes than proximal and distal parts of the femur. This result was consisted of studies in Chinese (14) and Croatians (5). The reason for this may be due to this area is not weight bearing and has less muscle attachment, which are the main causes of difference in size and robustness between male and female.

Multivariate discriminant function analysis from this study illustrates, the femoral head diameter (THD) and epicondylar breadth indicated the highest accuracy in this study, which similar to previous study in the Thai population (13)and reported in Croatian(5), South African and Japanese (10).While FND was not improve the accuracy of predicting when combine with THD, this result confirms FND has a lower ability to distinguish male from female than femoral head and epicondylar breadth.

There were many studies in sex estimation in several type of bones in the Thai population such as skull (23), sternum(24), vertebral column (25), humorous(26), talus (27), calcaneus (28), mastoid (29),metatarsal (30)and metacarpal (31, 32). To compare the femur with lower limb bones in the Thai population femur has the ability of prediction similar to talus and calcaneus. Thus in forensic context the femur is necessary, especially in the case of lower limb remains, which lack of pelvis and even in case of fragment femur proximal or distal end, can also use as tool for sex estimation. **However, the sample size of this study was not large and female samples were larger than male samples, this may affected the accuracy of sex's prediction.**

Conclusion

The femur is an important bone for sex estimation and proximal and distal of femur is the most important dimension of femur for sex estimation in Thai population. This study provides functions that can use in cases of complete or fragmented femur and all measurement methods are simple and suitable to be applied in forensic context. However, the accuracy is estimation related to the population and may change according to time .Thus data needs to be continuously updated

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