Estimation of Stature Using Fragmentary Femora Lengths in a Thai Population

Ilada Fongkete[1], Suda Riengrojpitak[2*], Pasuk Mahakkanukrauh[3*]
[1] Graduate Programme of Forensic Science, Faculty of Science, Mahidol University, Bangkok, Thailand
[2] Department of Pathobiology, Faculty of Science, Mahidol University, Bangkok, Thailand
[3] Department of Anatomy, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand
*Corresponding author, e-mail: suda.rie@mahidol.ac.th, pasuk034@gmail.com

Abstract

Identification of human remains by creating biological profiles is one of the most essential aspects in forensic investigations. Stature determination through procedures of already established equations in a Thai population requires the presence of one or more complete long bones. However, in real cases the bones are not always recovered intact, making the equations involving a complete long bone inappropriate. The present study aims to investigate the relationship between stature and fragmented femur measurements in Thais, and to derive regression equations for estimation of stature from femur measurements using the direct 1-step method and indirect 2-step method, and eventually to determine which method is best for the Thai population. The study sample consisted of 255 Thai adults (159 males and 96 females). Results have shown that the upper breadth (VHA) from males and maximum anteroposterior diameter of lateral condyle (LAP) from females as the best predictor for stature estimation and produced the lowest standard errors (SE) of 5.15 and 5.73 centimeters respectively. Comparison of the standard errors (SE) between the two methods revealed that estimating stature through the direct 1-step method is preferred.

Keyword Estimation, Stature, Femur, Regression, Thais

Background

Stature estimation is one of the basic principle analyses of the human bone in modern practical forensic casework and anthropological studies along with determination of sex, age, and ancestry. Other than creating a biological profile of an unknown individual, stature estimation may provide a valuable clue of that person when they are unusually short or tall. In already established works regarding stature estimation in a Thai population (1) requires the maximum lengths of the long bones. A condition that comes to question during every day criminal cases where the identity of a dead body may be destroyed by many factors, resulting in only fragmented bone pieces to be recovered from the crime scene. With only the fragmented bones, the regression equations using maximum lengths of intact complete long bones are inappropriate.

This problem has called for and has become the aim of this study to use the femur that correlates highly with stature, to derive regression equations to estimate the maximum length of femur from its fragments. Then the calculated femur lengths can be applied in another set of equations already established in previous works for stature estimation. This 2-step method will then be compared to the 1-step method of finding stature directly from the fragmented measurements. By doing so, this will benefit the process of identification and estimation of stature in cases where the bones are incomplete, a vague concept that has yet to be established in the Thai populations.

Materials and Methods

The study sample consisted of 255 left femur from Thai adults (159 males, 96 females) with an average age and stature of 65.65 years and 165.46 cm in males, and 66.34 years and 152.59 centimeters in females, respectively.

Seven measurements of the femur modified from previous works (2, 3) shown in Table 1 were taken using the osteometric board and a digital Vernier caliper. The measurements using SPSS for Windows were then used to derive regression equations to estimate stature directly (1-Step Method). And in the 2-Step method, the measurements were used to derive regression equations for estimation of maximum lengths first, then the maximum lengths were applied in an already existing set of equations conducted in an earlier study in a Thai population by Mahakkanukrauh et al. (1) to estimate stature. The standard errors (SE) from both methods were compared to determine which method was more applicable for the Thai population.

Results, Discussion and Conclusion

Results have shown that for the direct 1-step method of the male sample group, the upper breadth (VHA) measurement had the highest

correlation and coefficient of determination (R^2), while in the female group the max. anteroposterior diameter of lateral condyle (LAP) as the best predictor. (Tables 2 and 3)

Table 1 Femur measurements used in this study.

Measurements	Description
Maximum length of femur (FML)	Linear distance between the most superior part of the head of the femur and the most inferior part of the medial condyle
Vertical diameter of femoral head (VHD)	Linear distance between the highest and lowest points of the head in the vertical plane
Upper breadth of femur (VHA)	Linear measurement between the most superior point on the fovea capitis to the inferior aspect of the great trochanter
Minimum femoral neck diameter (FND)	Minimum linear distance between the superior and inferior points on the neck of the femur
Epicondylar breadth (FDL)	Linear distance between the most projected points on the epicondyles
Maximum anteroposterior diameter of medial condyle (MAP)	Linear distance on the medial condyle measured in an anteroposterior direction
Maximum anteroposterior diameter of lateral condyle (LAP)	Linear distance on the lateral condyle measured in an anteroposterior direction

To determine whether stature estimation using the 1-step method or the 2-step method provides the best results of stature estimation, the standard errors (SE) from the two methods were compared in Table 4. For all the femur measurements, the SE from both male and female samples was higher in the 2-step method. It is concluded that the direct 1-step method is preferred. This has also revealed that the best predictor for stature in males is the VHA with a SE of 5.15 and in females, the LAP with an SE of 5.85 centimeters.

Table 2 Regression equations for stature estimation using the 1-step method in the male sample group.

x	Equation	r	R^2
VHD	(19.698x)+81.157	0.61	0.37
VHA	(11.329x)+60.770	0.70	0.50
FND	(19.638x)+103.969	0.53	0.28
FDL	(11.203x)+75.776	0.55	0.30
MAP	(12.365x)+90.708	0.58	0.34
LAP	(14.778x)+75.956	0.65	0.42

Table 3 Regression equations for stature estimation using the 1-step method in the female sample group.

x	Equation	r	R^2
VHD	(11.512x)+108.636	0.40	0.16
VHA	(5.972x)+103.402	0.39	0.15
FND	(20.155x)+97.390	0.46	0.22
FDL	(8.413x)+92.742	0.38	0.14
MAP	(10.781x)+93.489	0.42	0.17
LAP	(16.546x)+61.019	0.59	0.34

Table 4 Comparison of standard errors (SE) between the two methods.

x	Male		Female	
	SE(1)	SE(2)	SE(1)	SE(2)
VHD	5.79	6.19	6.37	6.41
VHA	5.15	5.59	6.42	6.47
FND	6.21	6.55	6.14	6.21
FDL	6.07	6.40	6.06	6.16
MAP	5.85	6.18	6.18	6.26
LAP	5.55	5.94	5.73	5.85

This study has shown that by deriving regression equations for fragmented measurements of the femur, stature can be estimated even if the bones are damaged or incomplete. By using a Thai population sample group, this study could benefit the future forensic process of identification in Thailand.

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การประมาณความสูงจากชิ้นส่วนของกระดูก femur ในกลุ่มประชากรไทย

ไอลดา ฟองเกตุ, สุดา เรียงโรจน์พิทักษ์, ผาสุก มหรรฆานุเคราะห์

บทคัดย่อ

สำหรับนักนิติวิทยาศาสตร์แล้วการประมาณความสูง ระบุเพศ อายุ และเชื้อชาติ โดยการใช้กระดูกของมนุษย์นั้นเป็นสิ่งที่มีความสำคัญและน่าสนใจเป็นอย่างมาก เนื่องจากข้อมูลดังกล่าวสามารถบ่งบอกถึงข้อมูลของตัวบุคคลที่สูญหายได้ ในอดีตได้มีการทำวิจัยการประมาณความสูงจากกระดูกและได้พบว่ากระดูกที่มีความน่าเชื่อถือในการประมาณความสูงที่ดีที่สุดคือกระดูก femur แต่เนื่องจากกระดูกที่พบในที่เกิดเหตุอาจไม่สมบูรณ์เสมอไปจากสาเหตุต่างๆ ทำให้จุดประสงค์ของงานวิจัยนี้คือการหาความสัมพันธ์และสูตรที่เกิดจากชิ้นส่วนของกระดูก femur และความสูงโดยใช้สองวิธี (1-Step และ 2-Step method) เพื่อสรุปว่าวิธีไหนได้ผลดีกว่าในประชากรไทย ผลระบุว่าการใช้วิธี 1-Step เพื่อหาความสูงนั้นได้ค่า standard error (SE) ต่ำกว่าจึงเหมาะสมกว่าที่จะนำมาใช้ โดยตัวแปร upper breadth (VHA) ในเพศชายและ maximum anteroposterior diameter of lateral condyle (LAP) ในเพศหญิงได้ค่า SE ต่ำที่สุดจากตัวแปรทั้งหมด