ACCURACY FOR SEX DETERMINATION BY USING CRANIOSCOPY AND CRANIOMETRY

KOMON BOONKAEW

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Komon Boonkaew
....
Mr. Komon Boonkaew,
Candidate

Sanjai Sangvichien
....
Prof. Sanjai Sangvichian,
M.D., D.Sc.
Major advisor

Arraya Sangiampong
....
Assoc. Prof. Arraya Sangiampong,
M.Sc.
Co-advisor

Chulaluk Komoltri
....
Dr. Chulaluk Komoltri,
Dr.PH (Biostatistics)
Co-advisor

Aporn Chuncharunee
....
Assoc. Prof. Aporn Chuncharunee,
D.V.M., M.Sc.
Co-advisor

....
Assoc. Prof. Rassmidara Hoonsawat,
Ph.D.
Dean
Faculty of Graduate Studies

....
Assoc. Prof. Jantima Roongruangchai,
D.D.S., Ph.D.
Chair
Master of Science Programme
in Anatomy
Faculty of Medicine, Siriraj Hospital

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on
September 14, 2005

Komon Boonkaew
....
Mr. Komon Boonkaew,
Candidate

Sanjai Sangvichien
....
Prof. Sanjai Sangvichian,
M.D., D.Sc.
Chairman

....
Clin. Prof. Somchai Pholeamek,
M.D., L.L.B.
Member

....
Assoc. Prof. Arraya Sangiampong,
M.Sc.
Member

....
Dr. Chulaluk Komoltri,
Dr.PH (Biostatistics)
Member

....
Assoc. Prof. Aporn Chuncharunee,
D.V.M., M.Sc.
Member

....
Assoc. Prof. Rassmidara Hoonsawat,
Ph.D.
Dean
Faculty of Graduate Studies
Mahidol University

....
Clin. Prof. Piyasakol Sakolsatayadorn,
M.D.
Dean
Faculty of Medicine, Siriraj Hospital
Mahidol University

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Komon Boonkaew

ACCURACY FOR SEX DETERMINATION BY USING CRANIOSCOPY AND CRANIOMETRY

KOMON BOONKAEW 4436560 SIAN/M

M.Sc. (ANATOMY)

THESIS ADVISORS: SANJAI SANGVICHIAN, M.D., D.Sc.,
ARRAYA SANGIAMPONG, M.Sc., APORN CHUNCHARUNEE, D.V.M., M.Sc.,
CHULALUK KOMOLTRI, Dr.PH.

ABSTRACT

The purpose of this study was to evaluate sexual dimorphism in the cranium and mandible of Thais by using Cranioscopy (Krogman's method, modified Krogman's cranioscopy trait by grading and by measurement), Craniometry and Multiple Logistic Regression Analysis.

One hundred and one Thai skulls (66 males and 35 females) ranging in age from 18 to 86 years were used in this study. The mean age was 51.1 years. Evaluation of sexual dimorphism in the cranium and mandible of Thais was done using Cranioscopy (Krogman's cranioscopy, Modified Krogman's cranioscopy Trait by grading and by measurement), standard Craniometry and Multiple Logistic Regression Analysis.

Though the research was unexperienced, sex determination using *Krogman's cranioscopy* had a very high accuracy of 95.5% for males and 82.9% for females and an overall accuracy of 91.1%. Moreover, the Modified Krogman's Cranioscopy trait by grading and by measurement was also used in the sex determination of the skulls. *By craniometry*, the skull of a male was larger and higher than that of a female. Although 26 measurements showed a high degree of significance of the means, they had overlapping range which could not be definitely sexed by craniometry. As a result of craniometry, *Multiple Logistic Regression Analysis* can highly predict gender by using 4 measurements: nasion-basion length (M5), maximum breadth of the cranium (M8), facial length (M40), and bizygomatic breadth of the face (M45). It could correctly predict 82.9% (29/35) of females and 92.3% (60/65) of males respectively. The overall accuracy was 89% (89/100). This formula was

$$Z = -52.566 + 0.278\ M5 - 0.193\ M8 + 0.134\ M40 + 0.315\ M45$$

In conclusion, the cranioscopy studies based on 14 traits according to Krogman's suggestion is the best method for sex determination of individual unknown skulls.

KEY WORDS : CRANIUM/ CRANIOSCOPY/ MODIFIED CRANIOSCOPY/ CRANIOMETRY/ SEX DETERMINATION/

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ความแม่นยำในการแยกเพศโดยศึกษาลักษณะที่สังเกตได้เปรียบเทียบลักษณะที่วัดได้ของกะโหลก
(ACCURACY FOR SEX DETERMINATION BY USING CRANIOSCOPY AND CRANIOMETRY)

โกมล บุญแก้ว 4436560 SIAN/M

วท.ม. (กายวิภาคศาสตร์)

คณะกรรมการควบคุมวิทยานิพนธ์ : สรรใจ แสงวิเชียร, พ.บ., อารยา เสงี่ยมพงษ์, วท.ม., อาภรณ์ จันท์จารุณี, วท.ม., จุฬาลักษณ์ โกมลตรี, Dr.PH.

บทคัดย่อ

งานวิจัยมีจุดประสงค์เพื่อศึกษาการแยกเพศจากกะโหลกศีรษะและกระดูกคางของคนไทยด้วยวิธีของ Krogman โดยดูลักษณะของกะโหลก 14 ลักษณะ และดัดแปลงวิธีของ Krogman โดยดูลักษณะเป็นแบบลำดับและการวัดร่วมด้วย อีกแบบหนึ่งใช้วิธีวัดกะโหลกโดยใช้การวัดตามมาตรฐานของมนุษยวิทยากายภาพและคัดเลือกไปใช้ในการสร้างสูตรการวิเคราะห์การถดถอยแบบ logistic

การศึกษาโดยใช้กะโหลกคนไทยจำนวน 101 กะโหลก (ผู้ชาย 66 ผู้หญิง 35) ซึ่งมีช่วงอายุอยู่ระหว่าง 18-86 ปี เฉลี่ยอายุ 51.1 ปี ผลการศึกษาพบว่าการแยกเพศโดยใช้วิธีของ Krogman ในการดูลักษณะของกะโหลก 14 ลักษณะ สามารถแยกเพศชายได้ถูกต้อง 95.5 % และเพศหญิง 82.9 % โดยมีความแม่นยำรวม 91.1 % ส่วนการดัดแปลงวิธีของ Krogman โดยดูลักษณะเป็นแบบลำดับและการวัดกะโหลกสามารถแยกเพศได้เช่นกันโดยมีนัยสำคัญทางสถิติ ส่วนวิธีวัดกะโหลกโดยใช้การวัดตามมาตรฐานของมนุษยวิทยากายภาพซึ่งมี 26 วิธีวัด สามารถแยกเพศได้แต่มีค่าทับซ้อนกันระหว่างเพศชายและเพศหญิงจึงไม่สามารถแยกเพศจากกะโหลกศีรษะแบบอันเดียวได้ การวิเคราะห์การถดถอยแบบ logistic นั้น สามารถแยกเพศหญิงได้ถูกต้อง 82.9% (29/35) และเพศชาย 92.3% (60/65) ด้วยความแม่นยำรวม 89% (89/100) โดยมีสมการดังนี้

เมื่อ $Z = -52.566 + 0.278\ M5 - 0.193\ M8 + 0.134\ M40 + 0.315\ M45$

จากการทดลองนี้สรุปว่า การดูลักษณะของกะโหลก 14 ลักษณะตามวิธีของ Krogman แนะนำเป็นวิธีที่ดีที่สุดในการแยกเพศจากกะโหลกศีรษะแบบไม่ทราบเพศโดยกะโหลกอันเดียว

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LIST OF ABBREVIATIONS

b	Bregma
B_MASTOI	breadth of the base of mastoid process
B_OCCI	breadth of occipital condyle
ba	Basion
CI	95% confident interval
Ec	Ektokonchion
EX_OCCI	External occipital protuberance
g	Glabella
GLABELLA	Glabella region
gn	Gnathion
go	Gonion
H_MASTOI	height of mastoid process
I 1	Cranial index or Length-Breadth index
I 2	Length-height index
I 3	Breadth-height index
I 4	Transverse frontal index
I 5	Trasverse fronto-parietal index
I 7a	Sagittal frontal index
I 12	Facial index
I 15	Jugo-mandibular index
I 16	Alveolar index
I 18	Jugo-frontal index

LIST OF ABBREVIATIONS (CONT.)

I 19	Transverse cranio-facial index
I 20	Orbital index
I 26	Ramus index
I 27	Condylar index
ID	Identification
L_OCCI	length of occipital condyle
lc	Lacrimale
Lt	Left
M 1	Maximum length: Maximum length of the vault from glabella, in the median sagittal plane
M 5	Nasion-basion length
M 7	Basion-bregma
M 8	Maximum breadth: Maximum breadth of the vault, perpendicular to the median sagittal plane
M 9	Minimum frontal breadth: Shortest diameter between the two temporal Ridges
M 10	Maximum frontal breadth: Maximum transversal diameter along coronal suture
M 16	Breadth of foramen magnum (maximum)
M 17	Length of foramen magnum
M 23	Circumference: Circumference through glabella and opistocranium
M 24	Transversal arc (Porion-bregma-porion)

LIST OF ABBREVIATIONS (CONT.)

M 25	Median sagittal arc. Nasion-opistion
M 26	Nasion-bregma arc
M 29	Nasion-bregma cord
M 40	Facial length (basion-prosthion)
M 42	Lower facial length (basion-gnathion)
M 44	Biorbital breadth (Ektokonchion-ektokonchion)
M 45	Bizygomatic breadth (Maximum breadth)
M 47	Facial height (nasion-gnathion)
M 48	Upper facial height (nasion upper alveolar point)
M 49	Post. Interorbital breadth (lacrimale-lacrimale)
M 50	Ant. Interorbital breadth (Maxillofrontale-maxillofrontale)
M 51	Orbital breadth (maxillo-frontale-ektokonchion), Left
M 52	Orbital height (maximum perpendicular to orbit. Breadth), Left
M 57	Minimum breadth of nasal bones
M 57(I)	Maximum breadth of nasal bones
M 65	Bicondylar breadth (from most lateral point of one condyle to most lateral point of other)
M 66	Bigonial breadth (gonion-gonion)
M 70	Height of mandibular ramus (Gonion-highest point on condyle)
M 71	Breadth of mandibular ramus (Minimum breadth)
M 79	Mandibular angle (Between posterior border of ramus and inferior border of body) (Special instrument) (Mandibulometer)

LIST OF ABBREVIATIONS (CONT.)

M 80	length of occipital condyle (Lt)
M 81	breadth of occipital condyle (Lt)
mf	Maxillofrontale
mm	milimeter
n	Nasion
op	Opistocranion
ops	Opistion
po	Porion
pr	Prosthion ("prealveolar point")
SD	Standard deviation
SPINOUS	Spinous process
SPSS	Statistical Packages for Social Science
SUPRAOR	Supraorbital torus
zm	Zygomaxillare

CHAPTER I
INTRODUCTION

The sex determination of skeletons has always been of importance to Anthropology. The skeletons were useful in sex determination such as the femur, humerus, skull and pelvis. However, the skulls and pelvis were used to permit the diagnosis of sex with a high accuracy. Thus, the skull was of interest in this studying.

There are a number of factors which inveigh against a high degree of accuracy in the sexing of unknown material. Among them are the often fragmentary nature of the remains available for study; the evident age (at time of death) of the remains; and intrinsic variability. Most of the earlier studies of sex differences in the skull were centered on morphological traits in a descriptive manner (cranioscopy), whereas the recent studies were focused on morphometry or craniometry (e.g. discriminant function analysis) in a largely quantitative and statistical sense.

The scientists have found difference of the skull from the gender. The differences were summarized as follows (Romance JG, 1981; William PL, Warwick R, 1980). The skull of a female is lighter than that of a male and architecture is smoother; the muscular ridges are less pronounced; the mastoid processes are relatively small. The glabella and supercilliary arches are less prominent; the forehead is more vertical, and the frontal eminence appear to bulge more; the upper margin of the more rounded orbital opening is sharper; the parietal eminences are more convex. The facial region is rounder; the zygomatic region is lighter and more compressed. The palate tends to be smaller and to be parabolic in shape. The mandible is smaller and the height at the symphysis is less. The smoother the external surface of the squama of the occipital bone, the more likely the skull is female. The occipital condyles are smaller. The vertex is said to be more flattened and the relative height of the skull to be less.

Attempts to sex skulls by comparing selected dimensions have revealed considerable overlap in skulls of known sex. No single dimension is absolutely reliable but if all dimensions are either large or small then confidence increases in the assessment of sex of an unknown skull (Krogman, 1986). Cranial traits and dimensions have been assessed by Keen (1950) and discriminant analysis has been used to sex Japanese skulls by Hanihara (1959).

With regard to the Thai skull studies, there were only 2 reports. One report (Uttayanang, 1951), was the studied of cranial capacity and the cranial module in Thai and Chinese skulls. He has provided the statistic values such as mean, range, and index in the difference between Thai and Chinese skulls. The other report (Sangvichien, 1971), was the investigating of the difference between Thai and Chinese skulls in terms of physical anthropology by using cranioscopy and craniometry. He did not study sexual diagnosis of Thai skulls.

Thus, the present study was to evaluate sexual dimorphism in the cranium and mandible of Thais and modify cranioscopy and craniometry for sex determination. Then multiple logistic regression analysis has been used to determine sex Thai skulls.

CHAPTER II
OBJECTIVES

The present study was to evaluate sexual dimorphism in the cranium and mandible of Thais and modify cranioscopy and craniometry for sex determination. The specific aims were as follows:

1. To determine the accuracy of the cranioscopy by using Krogman's method,
2. To modify Krogman's cranioscopy trait by grading and measurement,
3. To determine the accuracy of craniometry by using standard measure method, and then to compare that accuracy with that of cranioscopy,
4. To determine sex from various measurements using the multiple logistic regression.

CHAPTER III
LITERATURE REVIEW

1. Skulls

The entire group of bones that make up the head is called the skull and it too can be divided into two primary groups: (1) cranium is the rounded area that houses and protects the brain. It is comprised of eight distinct bones that are fused together in an adult; (2) facial area is made up of fourteen separate bones, which include those that make up the jaws, cheeks and nasal area.

2. Cranioscopy

Cranioscopy is type of skull not study in measurement or can't measure by others measurement. It can tell by having or not having such as supraorbital foramen or types such as slight, medium or marked. Palatine torus can describe by size such as size of skull when look in the bottom. All of them call discontinuous characters or non-metrical character or discrete trait. The field of discrete trait of skull is cranioscopy be type can't measure. This important same measurement especially to study fossil of ancient of human because long time fossil may be destroy from long time under earth and cover by soil. That reason to difficult for measurement but cranioscopy can little do but if much more destroy can't do everything.

The scientists have found difference of the skull from the gender. The differences were as follows (Krogman WM, Íscan MY, 1986).

The mandible in the male is larger and thicker, with greater body height, especially at the symphysis, and with a broader ascending ramus; the gonial angle formed by body and ramus is less obtuse (under 125 degrees); the condyles are larger and the chin is "square"

The nasal aperture in the male is higher and narrower and its margins are sharp rather than rounded. The male nasal bones are larger and tend to meet in the midline at a sharper angle.

The orbits in the female are higher, more rounded and relatively larger, compared to upper facial skeleton. The orbital margins are sharper, less rounded, in the female than in the male.

The cheekbones are heavier in males and lighter in females. In the male, these bones are also described as medium to massive, in the female, slender to medium.

The supraorbital ridges are almost invariably much more strongly developed in the male than the female. Males range from moderate to excessive development, females from a mere trace to moderate. Heavy supraorbital ridges are typically male, while "trace" or "slight" are typically female.

The glabellar region, a large glabella is frequently associated with the male. It must be pointed out, however, that the range of variation is greater for the glabella than for ridges, with greater conver-gence toward an intermediate type.

The forehead contour in the female is higher, smoother, more vertical, and may be rounded to the point of forward protrusion; in general, the pattern is more pedomorphic. Frontal eminence in female is prominence than in male.

The mastoid processes are definitely larger in the male, and range in size from medium to large; in the female they are small to medium. The supramastoid crests show continuous with the zygomatic arches and are usually well developed in the male, smooth and less massive in the female.

The occipital region, the transverse lines are much more evident and the external occipital protuberance much larger in the male. A relatively smooth occipital bone is invariable female. The base of the skull shows larger occipital condyles, a relatively longer foramen magnum and has larger foramina in the male. The basilar portion of the occipital bone and the body of the sphenoid and longer in the male.

The palate is usually larger and broader in the male. The arch tends more toward a U-shape, owing to the relative length of the cheek tooth row; in the female the relative shortness of the cheek tooth row conduces to a more parabolic shape.

The teeth are slightly larger in the male, but the greater variability of tooth dimensions in the female tends to prevent sex discrimination on the basis of size.

Osman et al., (2001) studied about sexual diagnosis of the glabellar region of 90 Turkey skulls by photographs. The glabellar region was classified 4 phototypes (0 very smooth to 3 very rough). They revealed that 84% of males are in phototype 2 or higher but females are in type 1 or below.

3. Craniometry

Craniometry is the measurement of cranial features in order to classify people according to race, criminal temperament, intelligence, etc. The underlying assumption of craniometry is that skull size and shape determine brain size which determines such things as intelligence and capacity for moral behavior.

Keen (1950) attempted to set up cranial traits and dimensions for adult skulls which will determinr sex from skulls with 85 percent accuracy. He chose three basic anatomical features, namely supraorbital ridges, external auditory meatus, and external occipital protuberance and four measurements (maximum cranial length, facial breadth, depth of infratemporal fossa, and length of mastoid processes). For these four measurements, he calculated the mean and standard deviation for each sex. This gave a male range (179.4-191.8 mm), a female range (171.7-185.5 mm).

Hanihara (1959) presented his basic data used 8 variables include the following standard osteometric dimensions:

X1 maximum cranial length
X2 maximum cranial breadth
X3 cranial height (ba-br)
X4 facial breadth
X5 upper facial height
X6 bigonial breadth
X7 mandibular symphyseal height
X8 condylar height (gonion-condylion)
X9 minimum ramus breadth

Accuracy varies from 85.6 percent to 89.7 percent.

Hoshi et al. (1962) investigated the mastoid region. They revealed that 69% of male mastoid region had M type. According to this type, the apex of the process was directed vertically and there was a concavity immediately above the base of the process and below the supra mastoid crest) and 46% of females had F type. This type had a medially directed apex and the curvature of the skull was smooth and convex.

Boulinier (1969) tested two of the functions developed by Giles and Elliot (1963) on a sample of 100 French (50 males, 50 females) skulls. He noted that these two functions provide accuracy rates of 83 percent to 85 percent which are about the same as those of Giles and Elliot (1963) and indicated that there is a relationship between discriminant functions and age.

Demoulin (1972) investigated sexual differences in 10 cranial dimensions from a French sample by comparing the mastoid height and mastoid length with each other and with other dimensions. The results indicated that bizygomatic breadth, mastoid length, breadth of the zygomatic process and mastoid height were the most dimorphic. She then created several modules using combination of dimensions, and determined that the mastoid module (mastoid height x mastoid length) provided the best discrimination between the sexes.

Maryna et al. (1998) studied the sexual dimorphism in the crania and mandible of 91 South African White (44 males and 47 females) by using SPSS discriminant function analysis. The results showed the average range from 80% (bizygomatic breadth) to 86% (cranium).

Texeira (1981) concerned the possibility of sexual difference in the size of the foramen magnum. This research involved the surface area of the opening of the foramen magnum in 40 adult (20 males and 20 females) Brazilian skulls. He measured the length and breadth of the foramen and took the average of the two as an approximate diameter of a circle. His findings, based on this small sample, indicated that if the surface area of the foramen magnum is 963 mm^2 or larger it is male and of the surface area is 805 mm^2 or less it is female.

Misako (1998) studied the estimation of structure from somatometry of 124 Japanese cadaveric skulls. The regression equations calculated were as followed: stature in male = (diameter + circumference) x 1.35 + 70.6; stature in female = (diameter + circumference) x 1.28 + 87.8.

With regard to the Thai skull studies, there were only 2 reports. One report (Uttayanang, 1951), the researcher studied the cranial capacity and the cranial module in Thai and Chinese skulls. He has provided the statistic values such as mean, range, and index in the difference between Thai and Chinese skulls. The other report (Sangvichien, 1971), the researcher investigated the difference between Thai and

Chinese skulls in terms of physical anthropology by using cranioscopy and craniometry. He did not study sexual diagnosis of Thai skulls.

CHAPTER IV
MATERIALS AND METHODS

MATERIALS

A. Skulls

The skeletal material in this study came from cadaver collections housed at the Department of Anatomy, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand. One hundred and one adult Thai dried skulls (66 males and 35 females) ranged in age from 18 to 86 years were used in this study. The mean age was 51.1 years. They were identified Thais by their death certificates. All of the specimens were willed or donated (Figure M-1).

Figure M-1 The photograph of skulls

B. Craniometric Instruments

The craniometric instruments used in this study were obtained from dissecting rooms, or archaeological sites.

The instruments used to measure the skulls were (Figure M-2):

1. ***Sliding caliper*** is used for certain cranial measurements in facial region or mandible. The sliding caliper generally is the best choice of instrument when the reference points for a measurement are relatively close together and the contours of the skull do not interfere with the process of measuring, the sliding caliper generally is the best choice of instrument.
2. ***Hinge or spreading caliper*** is devised to enable one to measure points on the skull in which a straight-line-measuring device is not suitable.
3. ***Tape-measure*** was used to measure transversal arc, circumference, nasion-bregma arc, and median sagittal arc. The tape-measure which graded to millimeters was employed.
4. ***Mandibulometer*** is used to measure the mandible.
5. ***Sand bag*** is used to support the skull on flat surface for fixing the bone when measuring its.

Figure M-2 Craniometric instruments: Sliding caliper, Hinge or Spreading caliper, Tape-measure, Mandibulometer.

METHODS

A. Care of skulls

The finger was inserted into the foramen magnum for safety hold the skull but did not insert finger into another foramen such as the eyes orbits because these areas are composed many fragile bones.

B. Cranioscopy

Cranioscopy is divination and character analysis by studying the shape and structure of the human skull. It can tell by having or not having such as supraorbital foramen or types such as slight, medium or marked. Three methods of cranioscopy were used in this study:

1. **Krogman's Cranioscopy (Table M-1)**
2. **Modified Krogman's Cranioscopy Trait by Grading**
3. **Modified Krogman's Cranioscopy Trait by Measurement**

1. Krogman's Cranioscopy

Krogman's cranioscopy, based on 14 characteristics of skull, was used in sex determination (Table M-1, Appendix A)

Table M-1 Discrimination of gender according to Krogman's method.

Traits	Male	Female
General size	Large	Small
Architecture	Rugged	Smooth
Supraorbital ridge	Medium to large	Small to medium
Mastoid processes	Medium to large	Small to medium
Occipital area	Muscle lines and Protuberance marked	Muscle lines and protuberance not marked
Frontal eminences	Small	Large
Parietal eminence	Small	Large
Orbits	Squared, lower, relatively smaller,	Rounded, higher, relatively

	with rounded margins	larger, with sharp margins
Forehead	Steeper, less rounded	Rounded, full, infantile
Cheek bones	Heavier, more laterally arched	Lighter, more compressed
Mandible	Larger, higher symphysis, Broader ascending ramus	Small, with less corpal and ramus dimensions
Palate	Larger, broader, tends to U-shape	Small, tends to parabola
Occipital condyle	Large	Small
Teeth	Large, lower M1 more often 5 cusped	Small, more often 4 cusped

2. Modified Krogman's Cranioscopy Trait by Grading

In order to simplify gender classification, modified Krogman's cranioscopy trait by grading which was based on 3 characteristics of skull, namely supraorbital torus, glabella region, and external occipital protuberance was used as follows (Appendix A):

1. Supraorbital torus: 4 types
   - 0 = Smooth
   - 1 = Small
   - 2 = Medium
   - 3 = Large
2. Glabella region: 4 types
   - 0 = Smooth
   - 1 = Rough
   - 2 = More rough
   - 3 = Very rough
3. External occipital protuberance: 4 types
   - 0 = Protuberance not mark (smooth)
   - 1 = Rough
   - 2 = More rough
   - 3 = Very protuberance mark (very rough)

3. Modified Krogman's Cranioscopy Trait by Measurement

Four measurements of this method were recorded (Figure M-3, Appendix A):

1. Breadth of the base of mastoid process
2. Height of mastoid process
3. Length of occipital condyle (Lt)
4. Breadth of occipital condyle (Lt)

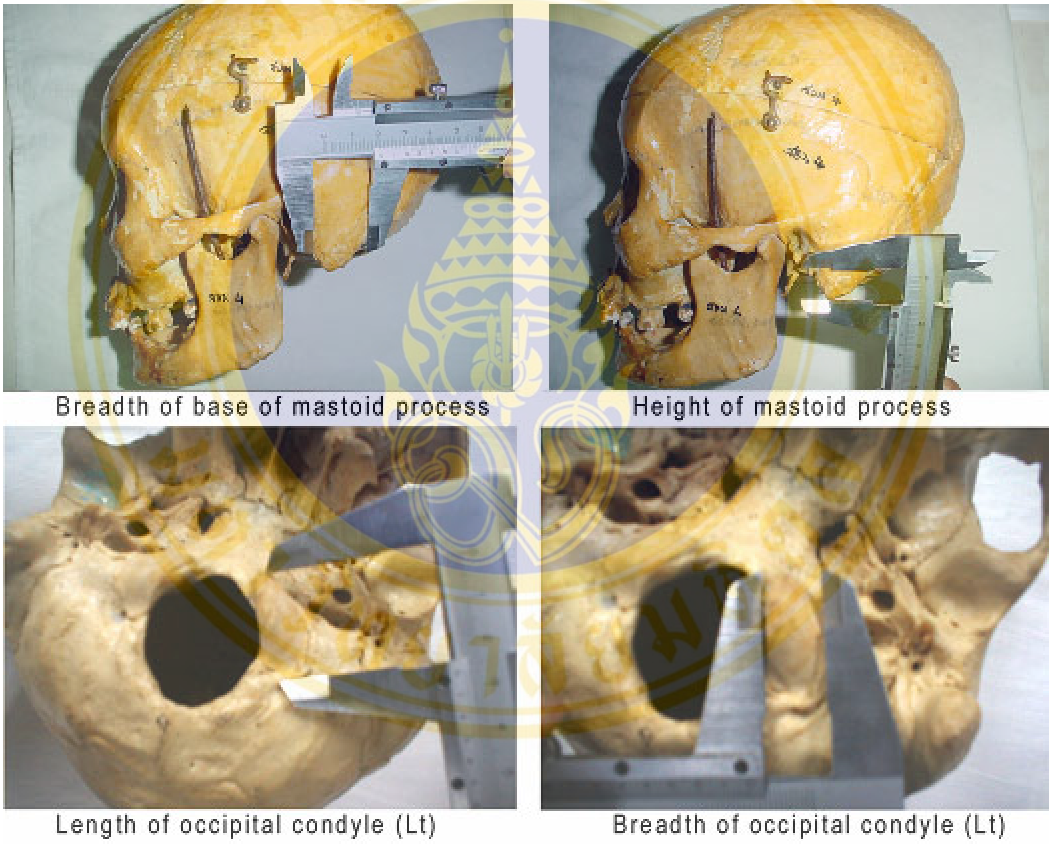

Figure M-3 Modified Krogman's Cranioscopy Trait by Measurement

C. Craniometry

Craniometry is the scientific measurement of the dimensions of the bones of the skull and face. It applies to measurement of the dry skull.

1. Landmarks

1.1 Median sagittal plane

1.2 Outside the median-sagittal plane

1.3 Mandible

2. Measurements and Index

1. The landmarks (Figures M-4, M-5, M-6)

1.1 Median sagittal plane

1. Nasion (n): The point where the sutura nasofrontalis crosses the median-sagittal plane.

2. Glabella (g): The most prominent point on the ridge between the supercilliary arches–in the median sagittal plane.

3. Bregma (b): The point where the sagittal suture joints the coronal. If this point is not in the midline, it is projected into the median sagittal plane.

4. Opistocranion (op): The most prominent point on the occiput, not the protuberentia occipitalis ext.

5. Opistion (ops): The point where the median–sagittal plane crosses the posterior border of the foramen magnum.

6. Basion (ba): The point where the median-sagittal plane crosses the anterior border of the foramen magnum. For the basion-facial measurements, the point is a little more posteriorly than the height measurements in which cases the point is generally located on the lower border of the foramen.

7. Prosthion ("prealveolar point") (pr): The most anterior point on the upper alveolar process.

1.2 Outside the median-sagittal plane

8. Porion (po): The midpoint on the upper border of the external auditory meatus.

9. Maxillofrontale (mf): The point where the frontomaxillary suture is crossed by crista lacrimalis anterior.

10. Lacrimale (lc): The point where the suture is crossed by the anterior lacrimale crista.

11. Ektokonchion (Ec): A line is drawn across the orbital opening, from the maxillofrontale, dividing the opening exactly into halves. The ektokonchion is situated where this line crosses the outer orbital border.

12. Zygomaxillare (zm): The lowest point on the zygomaticomaxillary suture.

1.3 Mandible

13. Gnathion (gn): The lowest point of the mandible in the median sagittal plane. (gn)

14. Gonion (go): The most lateral-posterior-inferior point of the mandibular angle.

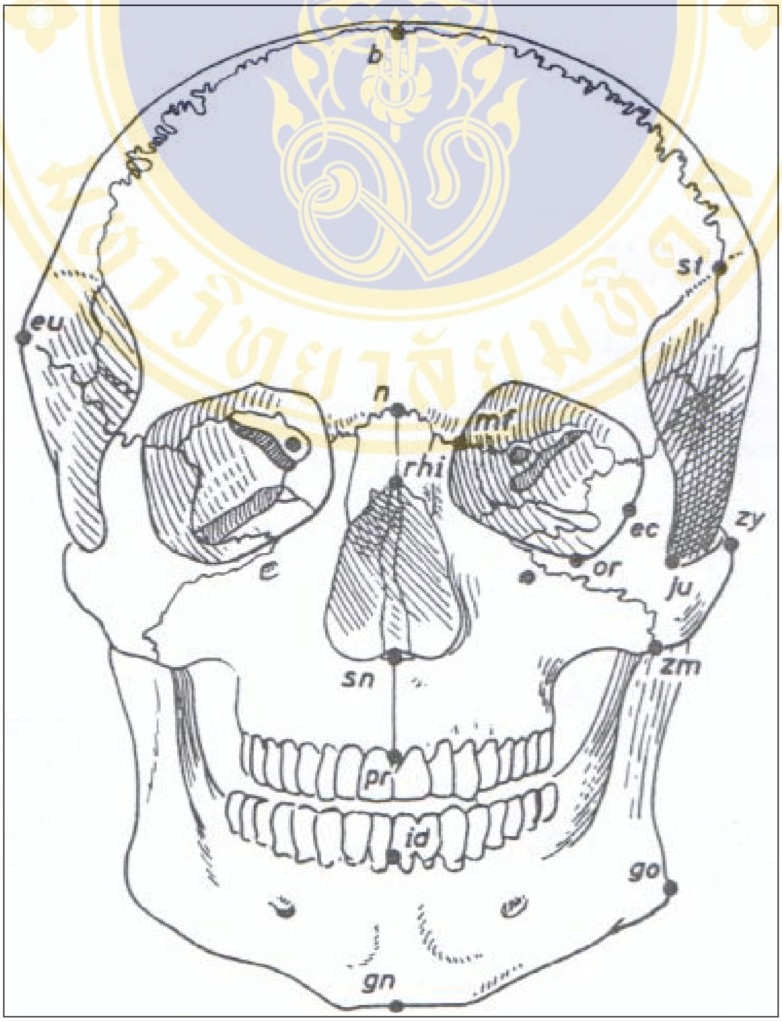

Figure M-4 Photograph of the anterior aspect of skull.

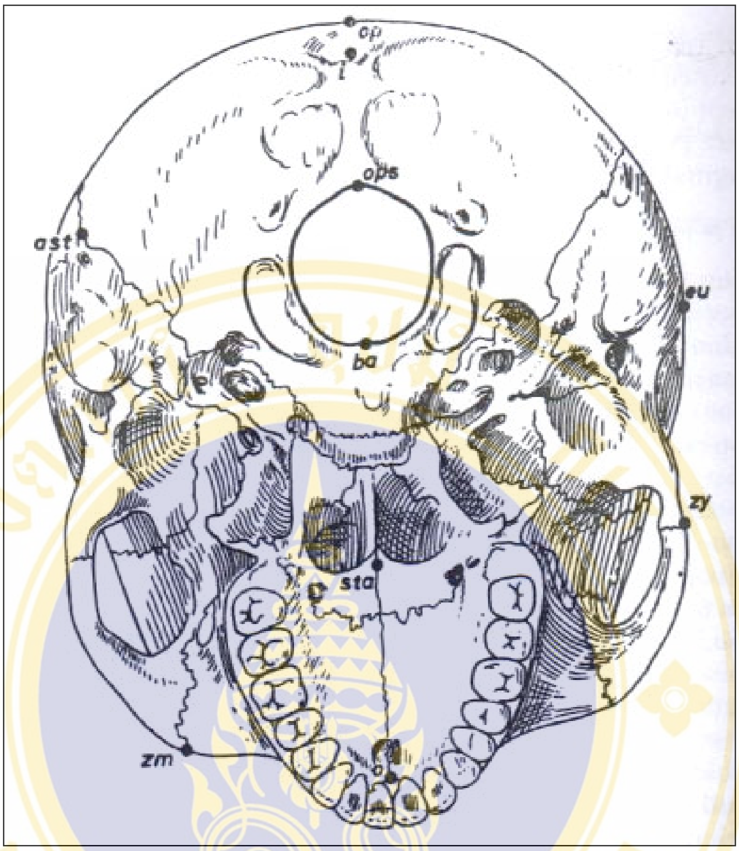

Figure M-5 Photograph of the base of skull

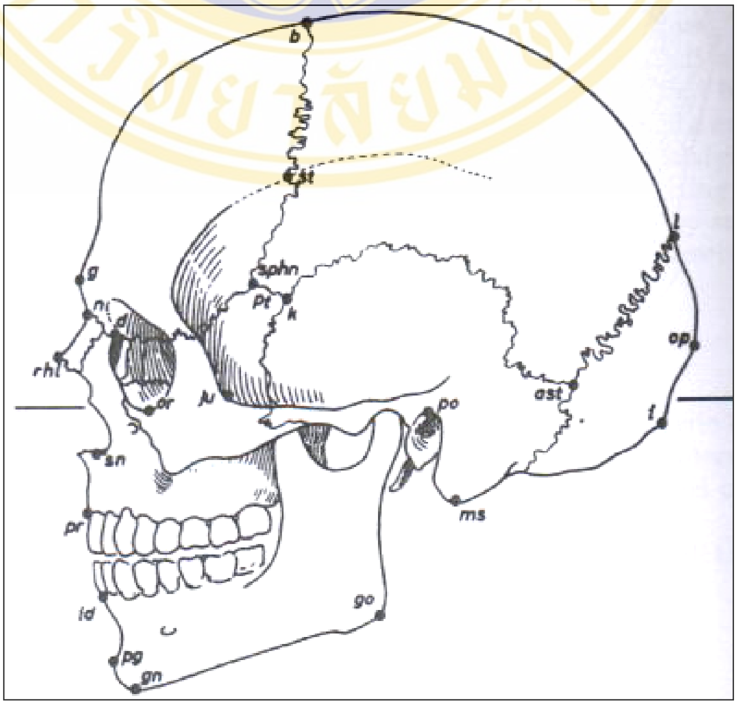

Figure M-6 Photograph of the lateral aspect of skull.

2. Measurements

The measurements taken in this analysis were (Appendix B):

M 1 Maximum length: Maximum length of the vault from glabella, in the median sagittal plane

M 5 Nasion-basion length

M 7 Basion-bregma

M 8 Maximum breadth: Maximum breadth of the vault, perpendicular to the median sagittal plane (Not including the zygomatic arches)

M 9 Minimum frontal breadth: Shortest diameter between the two temporal Ridges

M 10 Maximum frontal breadth: Maximum transversal diameter along coronal suture

M 16 Breadth of foramen magnum (maximum))

M 17 Length of foramen magnum

M 23 Circumference: Circumference through glabella and opistocranium

M 24 Transversal arc (Porion-bregma-porion)

M 25 Median sagittal arc. Nasion-opistion

M 26 Nasion-bregma arc

M 29 Nasion-bregma cord

M 40 Facial length (basion-prosthion)

M 42 Lower facial length (basion-gnathion)

M 44 Biorbital breadth (Ektokonchion-ektokonchion)

M 45 Bizygomatic breadth (Maximum breadth)

M 47 Facial height (nasion-gnathion)

M 48 Upper facial height (nasion upper alveolar point)

M 49 Post. Interorbital breadth (lacrimale-lacrimale)

M 50 Ant. Interorbital breadth (Maxillofrontale-maxillofrontale)

M 51 Orbital breadth (maxillo-frontale-ektokonchion), Left

M 52 Orbital height (maximum perpendicular to orbit. Breadth), Left

M 57 Minimum breadth of nasal bones

M 57(I) Maximum breadth of nasal bones

M 65 Bicondylar breadth (from most lateral point of one condyle to most lateral point of other)

M 66 Bigonial breadth (gonion-gonion)

M 70 Height of mandibular ramus (Gonion-highest point on condyle)

M 71 Breadth of mandibular ramus (Minimum breadth)

M 79 Mandibular angle (Between posterior border of ramus and inferior border of body) (Special instrument) (Mandibulometer)

Indices (Appendix B)

I 1 Cranial index or Length-Breadth index

$$= \frac{\text{Maximum breadth (M 8)} \times 100}{\text{Maximum length (M 1)}}$$

I 2 Length-height index

$$= \frac{\text{Basion-bregma height (M 7)} \times 100}{\text{Maximum length (M 1)}}$$

I 3 Breadth-height index

$$= \frac{\text{Basion-bregma height (M 7)} \times 100}{\text{Maximum breadth (M 8)}}$$

I 4 Transverse frontal index

$$= \frac{\text{Minimum frontal breadth (M9)} \times 100}{\text{Maximum frontal breadth (M10)}}$$

I 5 Transverse fronto-parietal index

$$= \frac{\text{Minimum frontal breadth (M 9)} \times 100}{\text{Maximum cranial breadth (M 8)}}$$

I 7a Sagittal frontal index

$$= \frac{\text{Nasion-bregma cord (M 29)}}{\text{Nasion-bregma arc (M 26)}} \times 100$$

I 11 Foramen magnum length-breadth index

$$= \frac{\text{Foramen magnum breadth (M 16)}}{\text{Foramen magnum length (M 7)}} \times 100$$

I 12 Facial index

$$= \frac{\text{Nasion-gnathion (M 47)}}{\text{Bizygomatic breadth (M 45)}} \times 100$$

I 15 Jugo-mandibular index

$$= \frac{\text{Bigonial (M 66)}}{\text{Bizygomatic (M 45)}} \times 100$$

I 16 Alveolar index

$$= \frac{\text{Facial length (M 40)}}{\text{Nasion-basion length (M 5)}} \times 100$$

I 18 Jugo-frontal index

$$= \frac{\text{Minimum frontal breadth (M 9)}}{\text{Bizygomatic breadth (M 45)}} \times 100$$

I 19 Transverse cranio-facial index

$$= \frac{\text{Bizygomatic breadth (M 45)}}{\text{Maximum breadth (M 8)}} \times 100$$

I 20 Orbital index

$$= \frac{\text{Orbital height (M 52)}}{\text{Orbital breadth (M 51)}} \times 100$$

I 26 Ramus index

$$= \frac{\text{Breadth of Mandibular ramus (M 71)}}{\text{Height of Mandibular ramus (M 70)}} \times 100$$

I 27 Condylar index

$$= \frac{\text{Breadth of occipital condyle (M 81)}}{\text{Length of occipital condyle (M 80)}} \times 100$$

D. Statistical data analysis

Data were analyzed using the SPSS 11.5. Accuracy of Krogman's craniscopy in males and females was reported as percentage along with 95% confidence interval (CI). Data from modified Krogman's cranioscopy trait by grading in male and female were compared using Chi-square test.

Craniometry measurements were reported as mean, standard deviation (SD), minimum and maximum. Measurements in males and females were compared using unpaired t-test. Multiple logistic regression analysis was employed to determine the combination of skull measurements that were the best predictors of gender.

CHAPTER V
RESULTS

The skulls in this study came from cadaver collections housed at the Department of Anatomy, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand. One hundred one adult Thai dried skulls (66 males and 35 females) ranged in age from 18 to 86 years were used in this study. The mean age was 51.1 years (SD = 17.3)

1. Cranioscopy

1.1 Krogman's Cranioscopy

1.2 Modified Krogman's Cranioscopy Trait by Grading

1.3 Modified Krogman Cranioscopy Trait by Measurement

2. Craniometry

2.1 Length, breadth and height of cranium

2.2 Basis cranii

2.3 Circumference and curve of skull

2.4 Median sagittal curve

2.5 Length, breadth and height of face

2.6 Orbit, interorbit

2.7 Nose and Mandible

2.8 Ratio of neuro- to viscero- cranium

3. Multiple Logistic Regression Analysis

1. Cranioscopy

1.1 Krogman's Cranioscopy

1.2 Modified Krogman's Cranioscopy Trait by Grading

1.3 Modified Krogman's Cranioscopy Trait by Measurement

1.1 Krogman's Cranioscopy

Table 1 showed discrimination of gender using Krogman's cranioscopy which is based on 14 external characteristics of skull. Krogman's method had a very high accuracy of 95.5% (63/66) (95% CI = 87.3%, 99.1%) for males and 82.9% (29/35)(95% CI = 66.4%, 93.4%) for females respectively and the overall accuracy of 91.1% (95% CI = 83.8%, 95.8%).

1.2 Modified Krogman's Cranioscopy Trait by Grading

Comparison of supraorbital torus revealed that mostly males had medium (36.4%) and large (33.3%) supraorbital torus whereas females had smooth (71.4%) and small (20.0%) supraorbital torus. For glabella region, it was mostly moderately rough (13.6%) and very rough (78.8%) among males but mostly smooth (65.7%) and rough (22.9%) among females. Males also had mostly moderately rough (29.2%) and very rough (58.5%) external occipital protuberance compared to mostly smooth (34.3%) and rough (54.3%) among females (Table 2).

1.3 Modified Krogman's Cranioscopy Trait by Measurement

Table 3 displayed comparison of trait measurements between males and females. For mastoid process, males had 4.53 mm wider base of mastoid process than females (23.83 vs. 19.30) with 95% CI of the difference between males of females of 2.58, 6.49. Mastoid process in males was 4 mm (95% CI = 2.33, 5.68) higher than females.

Regarding left occipital condyle, it was 1.62 mm (95% CI = 0.38, 2.86) longer and 0.85 mm (95% CI = 0.05, 1.65) wider for males than females. In terms of the ratio of breath to length of left occipital condyle, there was no statistically significant difference between males and females (50.55 vs. 50.45, p = 0.970).

Table 1 Discrimination of gender using Krogman' Cranioscopy which is based on 14 external characteristics of skull Krogman's method.

Recorded sex	**Number of predicted sex**	
	Male	**Female**
Male (n = 66)	63 (95.5%)	3 (4.5%)
Female (n = 35)	6 (11.1%)	29 (82.9%)

Table 2 Discrimination of gender using modified Krogman's cranioscopy trait by grading which is based on 3 external characteristics of skull.

Characteristics	Number		p-value
	Male (n = 66)	**Female** (n = 35)	
Supraorbital torus*			<0.001
Smooth	4 (6.1%)	25 (71.4%)	
Small	16 (24.2%)	7 (20.0%)	
Medium	24 (36.4%)	1 (2.9%)	
Large	22 (33.3%)	2 (2.7%)	
Glabella region*			<0.001
Smooth	1 (1.5%)	23 (65.7%)	
Rough	4 (6.1%)	8 (22.9%)	
Moderately rough	9 (13.6%)	2 (5.7%)	
Very rough	52 (78.8%)	2 (5.7%)	
External occipital protuberance*			<0.001
Smooth	0	12 (34.3%)	
Rough	8 (12.3%)	19 (54.3%)	
Moderately rough	19 (29.2%)	2 (5.7%)	
Very rough	38 (58.5%)	2 (5.7%)	

* $p < 0.05$

Table 3 Discrimination of gender using modified Krogman's cranioscopy trait by measurement which is based on 4 measurements and 1 index of skull.

Measurements	Sex	n	Mean	SD	Min, Max	Difference (M-F)		
						Mean	**95% CI**	**p-value**
Breadth of the base of mastoid process*	M	66	23.83	5.04	15.0, 38.0	4.53	2.58, 6.49	<0.001
	F	35	19.30	3.99	11.5, 31.0			
Height of mastoid process*	M	66	17.59	5.13	8.5, 28.5	4.01	2.33, 5.68	<0.001
	F	35	13.59	3.32	6.0, 22.5			
Length of occipital condyle (Lt)*	M	66	21.77	2.91	13.5, 28.0	1.62	0.38, 2.86	0.011
	F	35	20.14	3.13	12.0, 27.0			
Breadth of occipital condyle (Lt)*	M	66	10.77	1.78	7.0, 14.5	0.85	0.05, 1.65	0.037
	F	35	9.91	2.17	7.0, 17.5			
Breadth/Length of occipital condyle	M	66	50.55	11.87	28.9, 82.4	0.10	-5.10, 5.29	0.970
	F	35	50.45	13.68	29.2, 87.5			

* $p < 0.05$

2. Craniometry

The measurements taken in this analysis were:

2.1 Length, Breadth and Height of Cranium

2.2 Basis cranii

2.3 Circumference and Curve of skull

2.4 Median sagittal curve

2.5 Length, Breadth and Height of Face

2.6 Orbit, Interorbit

2.7 Nose and Mandible

2.8 Ratio of Neuro- to Viscero- cranium

2.1 Length, Breadth and Height of Cranium (Table 4, Figures 1-7)

Table 4 demonstrated comparison of length, breadth and height of cranium between males and females. The maximum length of cranium (M1) in males was 6.88 mm significantly longer than females with 95% CI of the difference of 4.00, 9.77.

Regarding different measurements for breadth of the cranium, maximum breadth (M8) in males was only 1.17 mm (95% CI = -1.06, 3.39) wider than females and it was not statistically significant different ($p = 0.300$). On the other hand, minimum (M9) and maximum (M10) frontal in males were 3.93 mm (95% CI = 1.51, 6.34) and 2.72 mm (95% CI = 0.02, 5.41) wider than females respectively. In terms of ratio of M9 to M10 (transverse frontal index), males seemed to have a higher ratio than females (67.13 vs. 65.33), but it was not significantly different ($p = 0.107$). The M9/M8 ratio (transverse fronto-parietal index) in males was significantly higher than females (56.09 vs. 53.81, $p = 0.005$).

For Basion-bregma height of cranium (M7), it was 6.23 mm (95% CI = 3.97, 8.50) higher for males than females.

Males had significantly lower cranial index (M8/M1) than females (83.07 vs. 85.84) but higher breadth-height index (M7/M8) (97.52 vs. 94.04). There was no significant difference in length-height index (M7/M1) between males and females (80.97 vs. 80.56, $p = 0.599$).

2.2 Basis cranii (Table 5, Figures 8-10)

Comparison of basis cranii between males and females (Table 5) showed that males had 7.20 mm (95% CI = 5.45, 8.95) longer nasal-basion (M5) than females. Foramen magnum in males was 1.37 mm (95% CI = 0.14, 2.60) longer and 1.21 mm wider (95% CI = 0.33, 2.08) than females. However, there was no significant difference in the ratio of length to breadth of foramen magnum between males and females (19.04 vs. 19.03, p = 0.975).

2.3 Circumference and Curve of skull (Table 6, Figures 11-13)

Table 6 revealed that males had 7.05 mm longer horizontal circumference than females (95% CI = 1.19, 12.92). The transverse arc and median sagittal arc in males were as much as 8.56 (95% CI = 3.68, 13.45) and 9.77 (95% CI = 3.95, 15.60) longer than females.

2.4 Median sagittal Curve (Table 7, Figure 14-15)

Comparison of single component of median sagittal curve (Table 7) showed that males had 4.39 mm (95% CI = 1.70, 7.09) and 3.69 mm (95% CI = 1.56, 5.83) longer nasion-bregma arc (M26) and nasion-bregma cord (M29) than females. However, there was no significant difference in the ratio of M29 to M26 (sagittal-frontal index) between males and females (83.55 vs. 83.53, p = 0.963).

2.5 Length, Breadth and Height of Face (Table 8, Figure 16-21)

In terms of various face measurements (Table 8), males had the following measurements significantly higher than females: face height (M40) 6 mm higher (95% CI = 3.63, 8.39), lower facial length (M42) 5.42 mm longer (95% CI = 2.08, 8.76), biorbital breadth (M44) 4.70 mm wider (95% CI = 3.08, 6.32), bizygomatic breadth (M45) 8.78 mm wider (95% CI = 6.44, 11.11), face height (M47) 10 mm higher (95% CI = 3.50, 16.50) and upper face height (M48) 4.98 mm higher (95% CI = 2.85, 7.10) respectively. For the ratio of M47 to M45 (facial index), there was no significant difference between males and females (79.76 vs. 77.35, p = 0.338).

2.6 Orbit, Interorbit (Table 9, Figure 22-25)

For orbit, males had significantly 2 mm (95% CI = 1.17, 2.85) wider orbit (M51) than females (Table 9). However, there was no statistically significant difference in the height of orbit (M52) between females and males (33.44 vs. 32.89, p = 0.255). Regarding the ratio of height to breadth of orbital (M52/M51), males had significantly lower ratio than females (83.50 vs. 86.61, p = 0.027).

For anterior and posterior interorbital breadth, they were 1.25 (95% CI = 0.30, 2.20) and 1.75 (95% CI = 0.82, 2.69) wider in males than females.

2.7 **Nose and Mandible** (Table 10, Figure 26-30)

Table 10 displayed the difference in nose and mandible measurements between males and females. Males had minimum breadth of nasal bone (M57) 0.83 mm wider than females (95% CI = 0.06, 1.61). Males also seemed to have maximum breadth of nasal bone (M57.1) 0.59 mm wider than females but it was not statistically significant difference (p = 0.146).

Regarding mandible measurements, men had 5.55 mm (95% CI = 3.08, 8.02) wider bicondylar breadth and 6.71 mm (95% CI = 4.39, 9.03) wider bigonial breadth than females. Mandibular ramus in males was as much as 6.26 mm higher (M70) and 2.69 mm wider (M71) than females. However, there was no significant difference in mandibular angle (M79) between males and females (119.83 vs. 121.97, p = 0.166), in mandibular ramus index (48.63 vs. 48.86, p = 0.855) and in jugo-madibular index (71.56 vs. 71.20, p = 0.624) respectively.

2.8 **Ratio of Neuro- to Viscero- cranium** (Table 11, Figure 31)

Table 11 demonstrated that there was no significant difference in alveolar index and jugo-frontal index between males and females (Alvelor index: 94.16 vs. 95.06, p = 0.456; Jugo-frontal index: 59.97 vs. 60.97, p = 0.180). However, cranio-facial index for males was as much as 5.32 mm higher than females (95% CI = 3.77, 6.87).

From table 4-11, most of the means of measurements and some indices of the cranium were highly significant different between males and females and the overlap of the male and female was also very small (Figure 1-31)

3. Multiple Logistic Regression Analysis

Table 12 displayed results of multiple logistic regression analysis based on 100 skulls with complete measurements. Four skull measurements, nasion-basion length (M5), maximum breadth of the cranium (M8), facial length (M40), and bizygomatic breadth of the face (M45), were found to be more significant predictors of gender than other measurements and indices. These 4 measurements all together could correctly predict 82.9% (29/35) of females and 92.3% (60/65) of males respectively. The overall accuracy was 89% (89/100). The multiple logistic regression equation used to predict gender was as followed:

$$P = \text{Probability of being male}$$

$$= \frac{e^{Z}}{1 + e^{Z}}$$

$$1 - P = \text{Probability of being female}$$

where e (consrant value) = 2.718

$$\mathbf{Z = -52.566 + 0.278\ M5 - 0.193\ M8 + 0.134\ M40 + 0.315\ M45}$$

To validate the above formula, 32 unknown skulls (Appendix C) were measured 4 measurements (M5, M8, M40, M45). The probability being male was equation from logistic regression analysis. It was found that the logistic regression equation could correctly predict 41.67% (5/12) of females and 90% (18/20) of males respectively. The overall accuracy was 71.88% (23/32).

Therefore, the cranioscopy study which is based on 14 traits according to Krogman's suggestion is the best method for sex determination of individual unknown skulls. It has been claimed that morphology can give a better indicator of sex. Moreover, if we used cranioscopy with craniometry together may predict gender more high accuracy.

Table 4 Comparison of Length, Breadth, Height, and Ratio of length,breadth and height of cranium between males and females.

Measurements	Sex	n	Mean	SD	Min, Max	Difference (M-F)		
						Mean	95% CI	p-value
Length of cranium								
M1 (Maximum length)*	M	66	175.68	6.83	160, 190	6.88	4.00, 9.77	<0.001
	F	35	168.80	7.18	155, 185			
Breadth of cranium								
M8 (Maximum breadth)	M	65	145.82	5.20	135, 158	1.17	-1.06, 3.39	0.300
	F	35	144.66	5.59	130, 155			
M9 (Minimum frontal breadth)*	M	66	81.73	5.58	70, 100	3.93	1.51, 6.34	0.002
	F	35	77.80	6.27	65, 90			
M10 (Maximum frontal breadth)*	M	65	121.92	6.55	100, 132	2.72	0.02, 5.41	0.048
	F	35	119.20	6.33	100, 130			
M9/M10 (Transverse frontal index)	M	65	67.13	5.49	56.0, 85.0	1.80	-0.39, 3.99	0.107
	F	35	65.33	4.82	54.4, 75.0			
M9/M8 (Transverse fronto-Parietal index)*	M	65	56.09	3.67	48.3, 64.5	2.28	0.69, 3.87	0.005
	F	35	53.81	4.10	44.2, 64.3			

Measurements	Sex	n	Mean	SD	Min, Max	Difference (M-F)		
						Mean	95% CI	p-value
Height of cranium								
M7 (Basion-bregma height)*	M	66	142.09	5.35	130, 155	6.23	3.97, 8.50	<0.001
	F	35	135.86	5.67	120, 145			
Ratio of length, breadth, height								
M8/M1 (Cranial index)*	M	65	83.07	4.13	73.7, 91.2	-2.77	-4.58, 0.95	0.003
	F	35	85.84	4.79	75.7, 95.5			
M7/M1 (Length-height index)	M	66	80.97	3.80	73.0, 93.8	0.41	-1.13, 1.96	0.599
	F	35	85.84	3.56	73.9, 90.6			
M7/M8 (Breadth-height index)*	M	65	97.52	4.87	88.4, 110.7	3.48	1.44, 5.53	0.001
	F	35	94.04	5.00	80.0, 103.7			

* $p < 0.05$

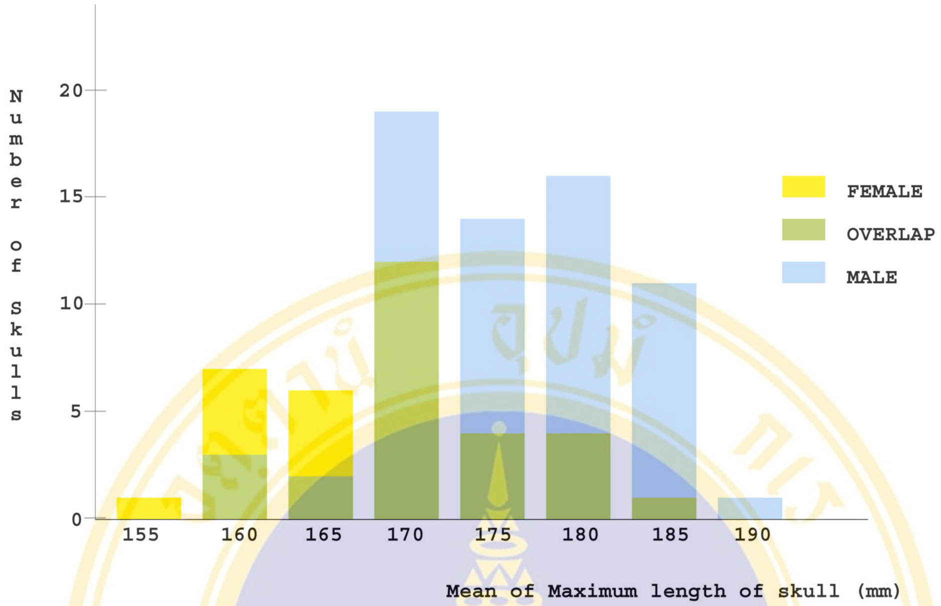

Figure 1. Distribution of Maximum length of skull (M1)

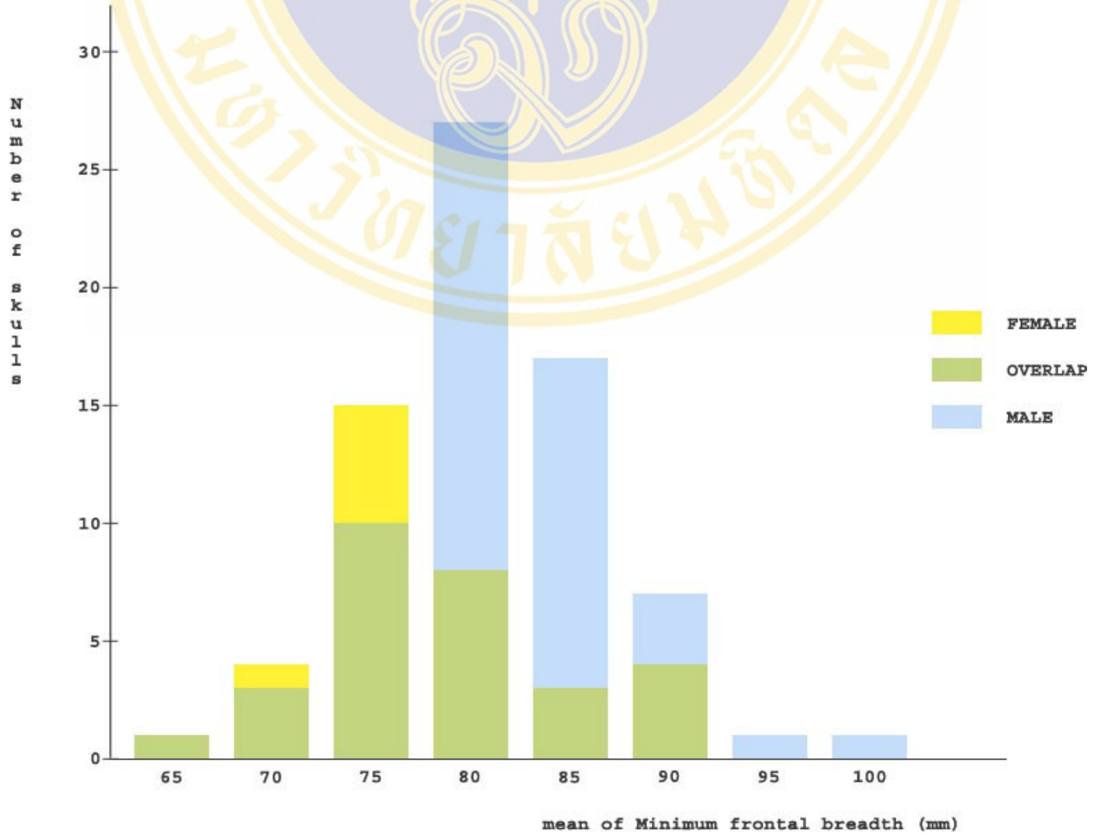

Figure 2. Distribution of Minimum frontal breadth (M9)

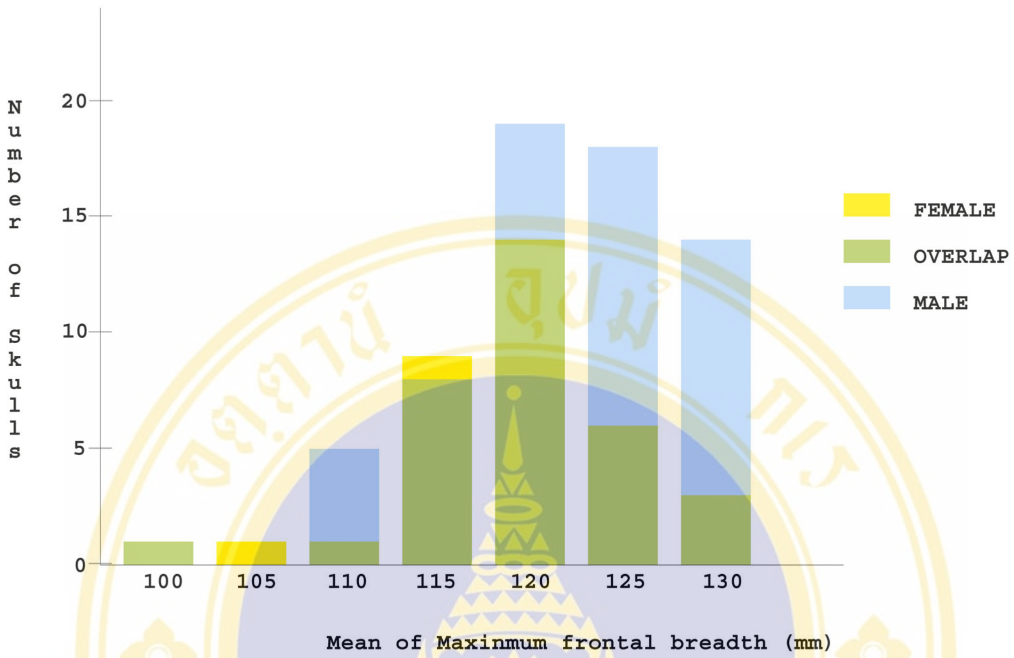

Figure 3. Distribution of Maximum frontal breadth (M10)

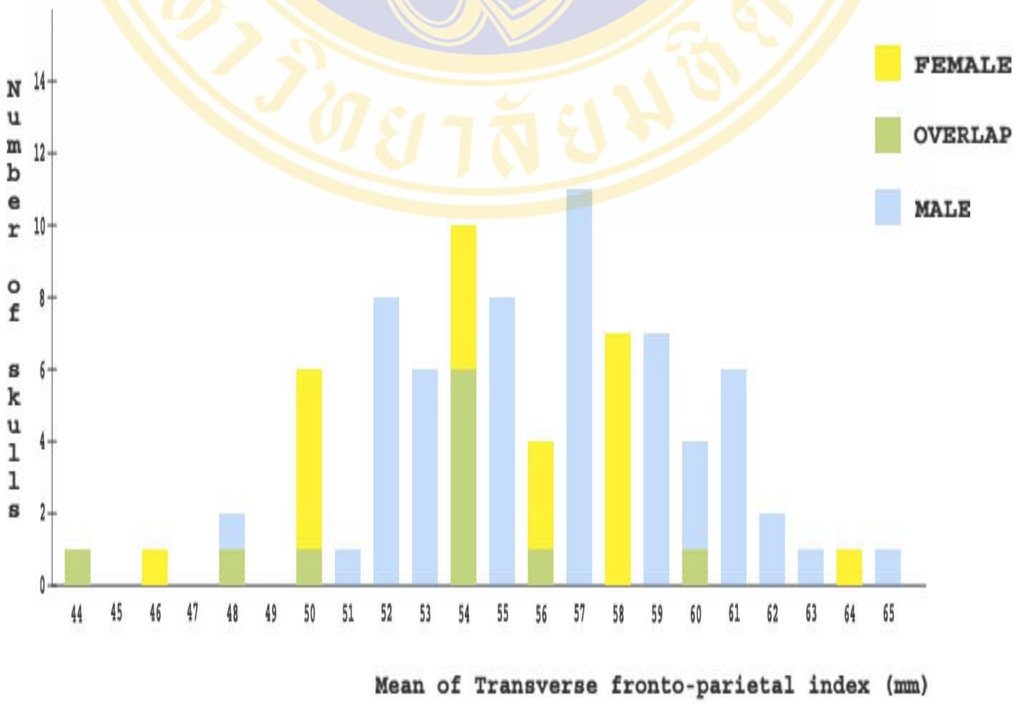

Figure 4. Distribution of Transverse fronto-parietal index (M9/M8)

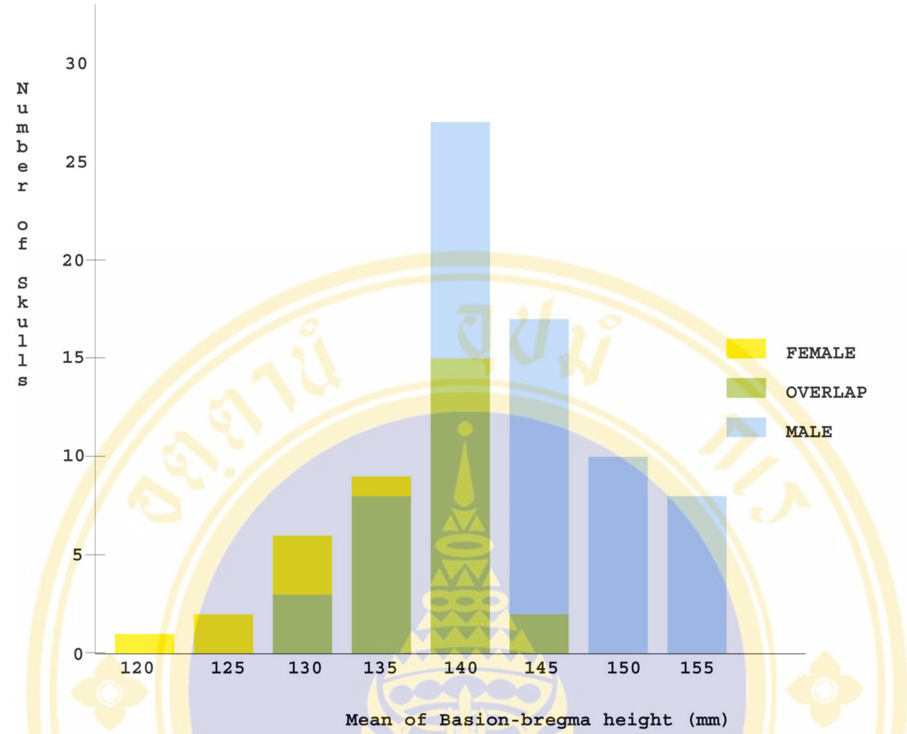

Figure 5. Distribution of Basion-bregma height (M7)

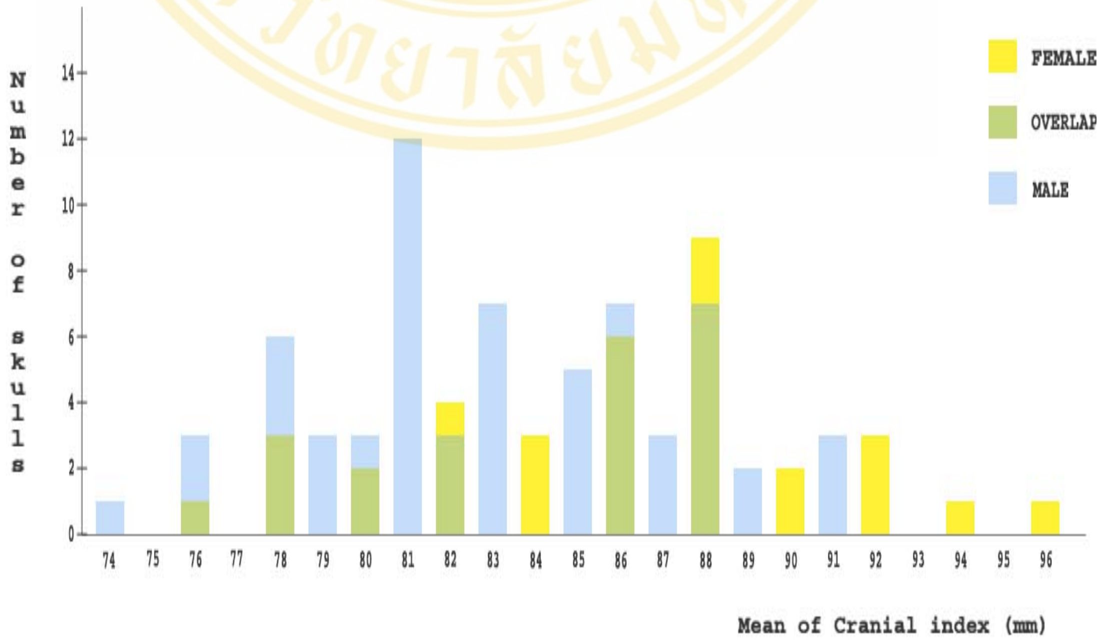

Figure 6. Distribution of Cranial index (M8/M1)

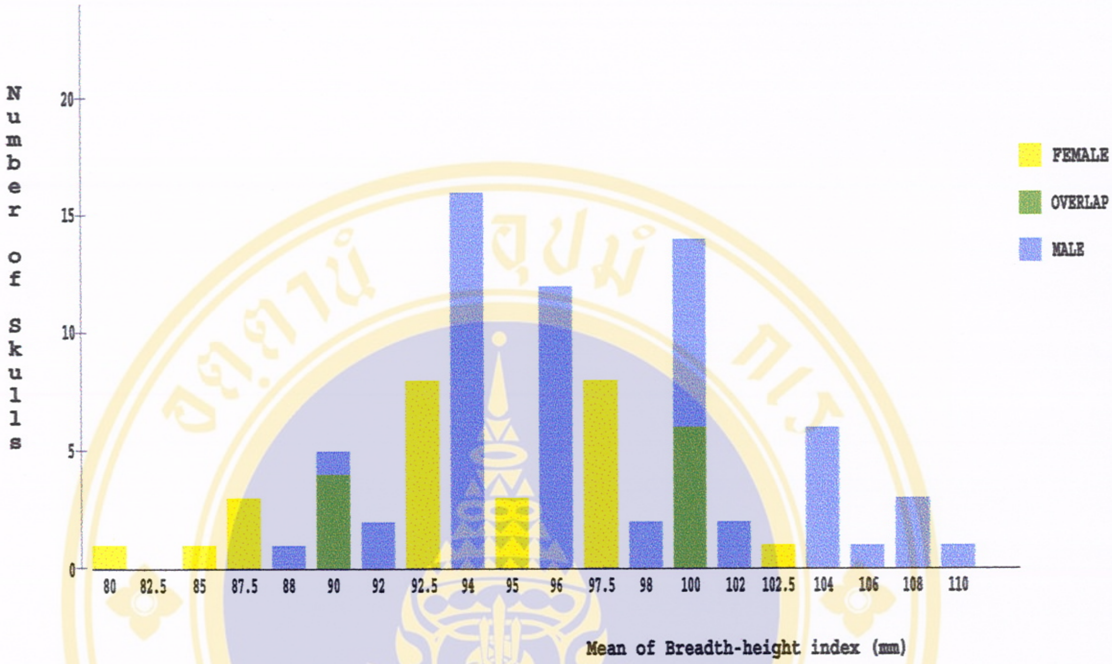

Figure 7. Distribution of Breadth-height index (M7/M8)

Table 5 Comparison of Basis cranii between males and females.

Measurements	Sex	n	Mean	SD	Min, Max	Difference (M-F)		
						Mean	95% CI	p-value
M5 (Nasion-basion length)*	M	66	101.77	4.10	95, 110	7.20	5.45, 8.95	<0.001
	F	35	94.57	4.43	90, 105			
M17 (Foramen magnum length)*	M	65	32.42	3.10	23, 39	1.37	0.14, 2.60	0.030
	F	35	31.06	2.66	27, 39			
M16 (Foramen magnum breadth)*	M	66	27.04	2.22	21.5, 32.0	1.21	0.33, 2.08	0.007
	F	35	25.83	1.88	21.0, 30.0			
M16/M17 (Foramen magnum length-breadth index)	M	66	19.04	1.60	15.7, 23.1	0.01	-0.63, 0.65	0.975
	F	35	19.03	1.47	16.2, 21.7			

* $p < 0.05$

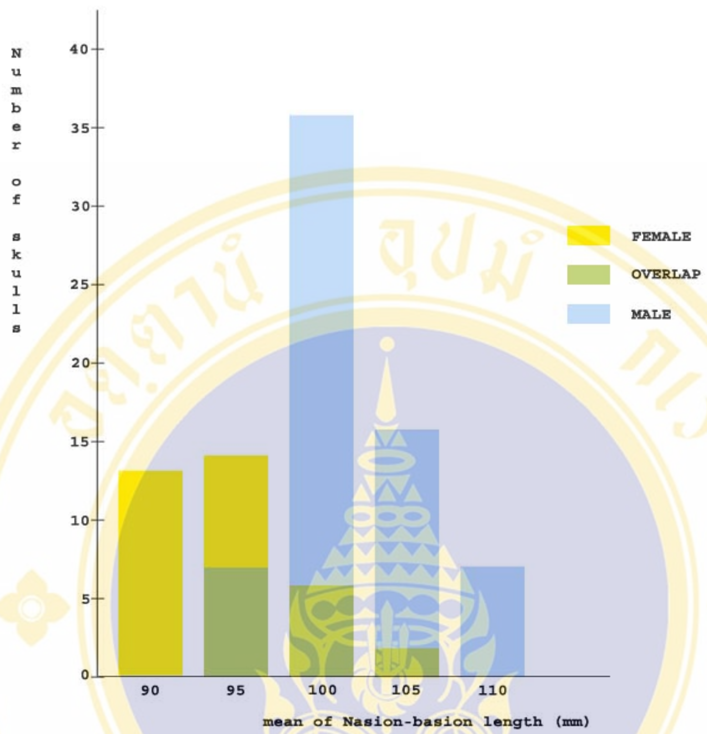

Figure 8. Distribution of Nasion-basion length (M5)

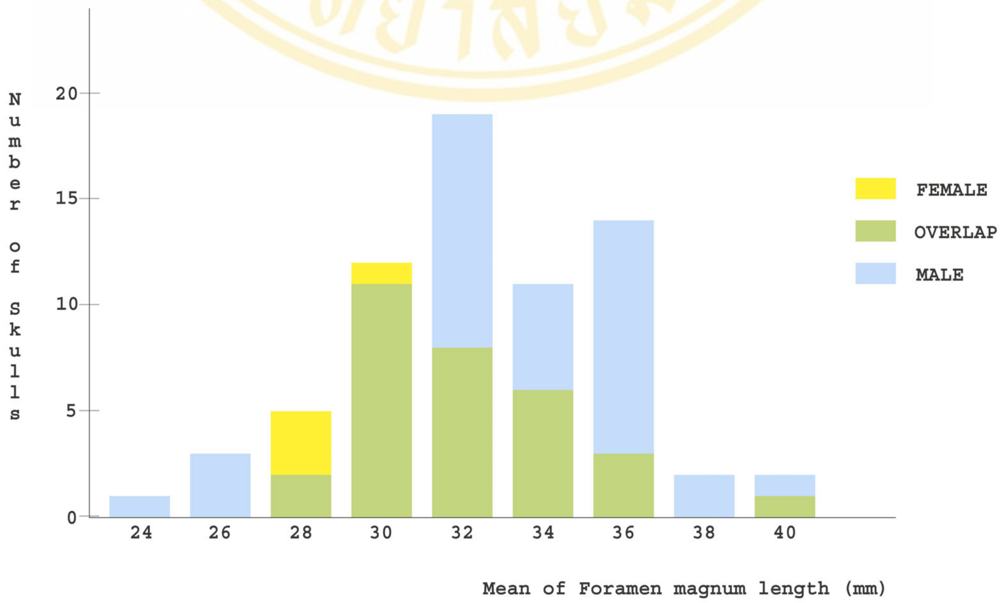

Figure 9. Distribution of Foramen magnum length (M17)

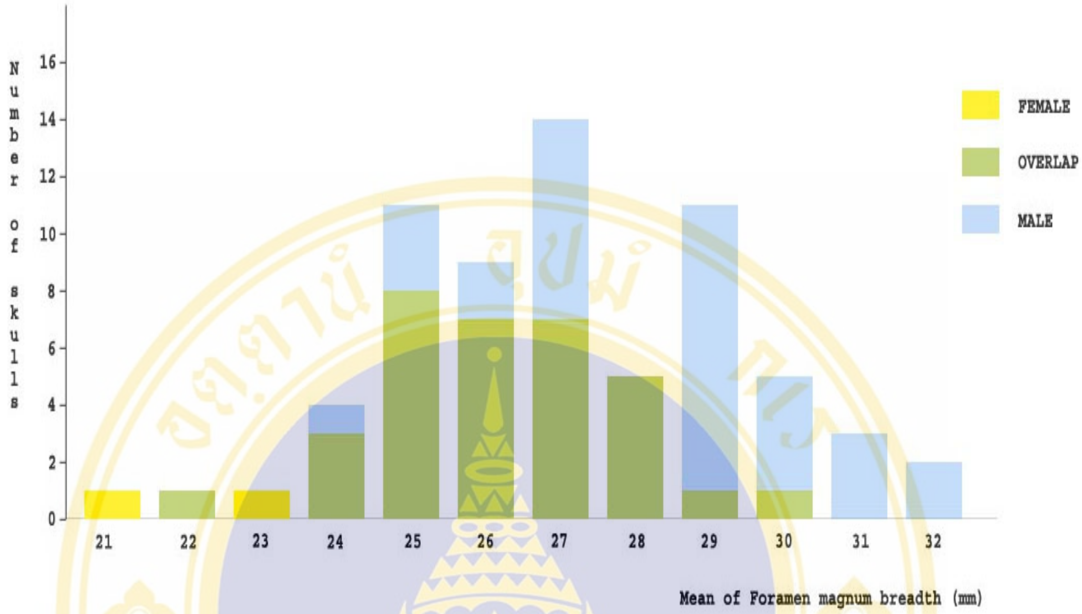

Figure 10. Distribution of Foramen magnum breadth (M16)

Table 6 Comparison of Circumference and curve of skull in males and females.

Measurements	Sex	n	Mean	SD	Min, Max	Difference (M-F)		
						Mean	95% CI	p-value
M23 (Horizontal circumference)*	M	66	101.77	4.10	95, 110	7.20	5.45, 8.95	<0.001
	F	35	94.57	4.43	90, 105			
M24 (Transverse arc)*	M	65	320.14	12.42	290, 355	8.57	3.68, 13.45	0.001
	F	35	311.57	10.34	295, 335			
M25 (Median sagittal arc)*	M	65	371.03	13.90	340, 410	9.77	3.95, 15.60	0.001
	F	35	361.26	14.18	325, 392			

* $p < 0.05$

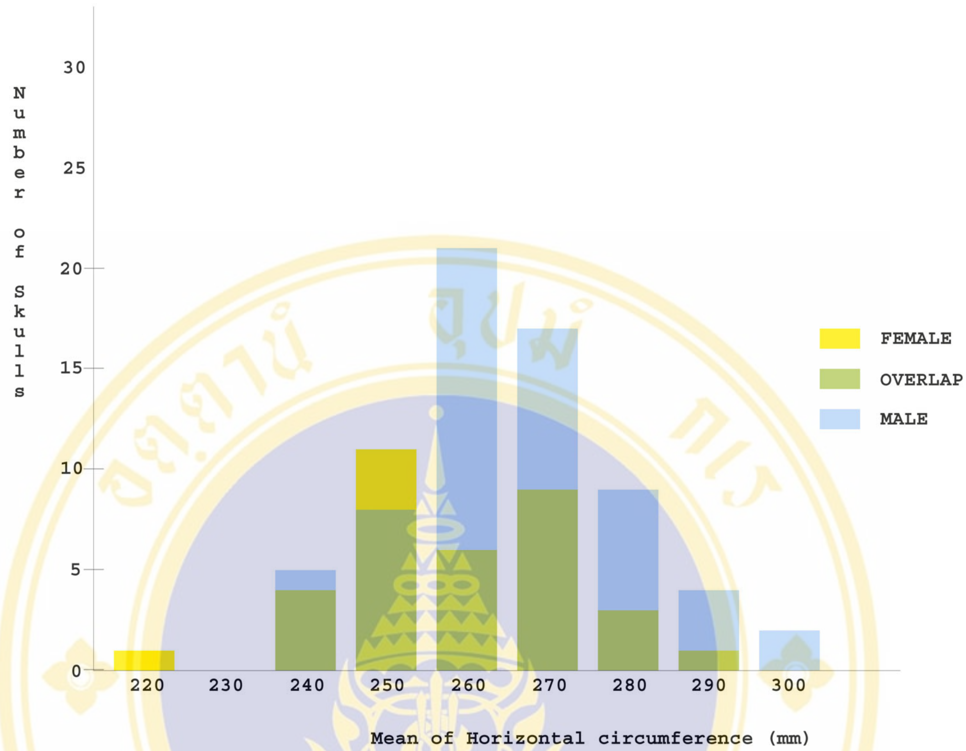

Figure 11. Distribution of Horizontal circumference (M23)

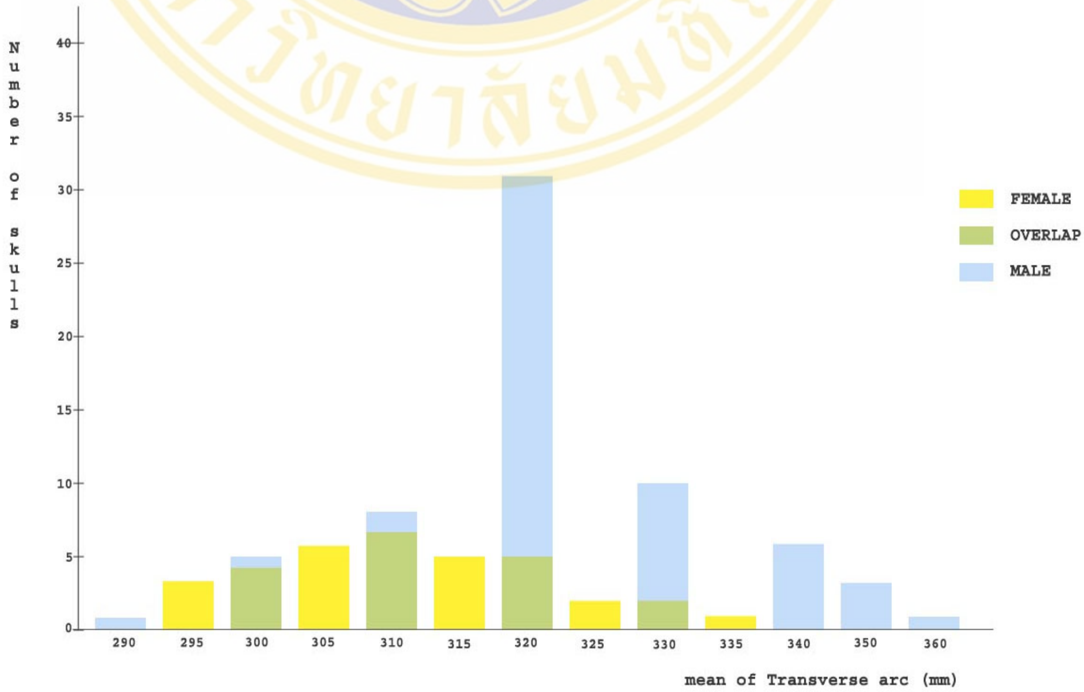

Figure 12. Distribution of Transverse arc (M24)

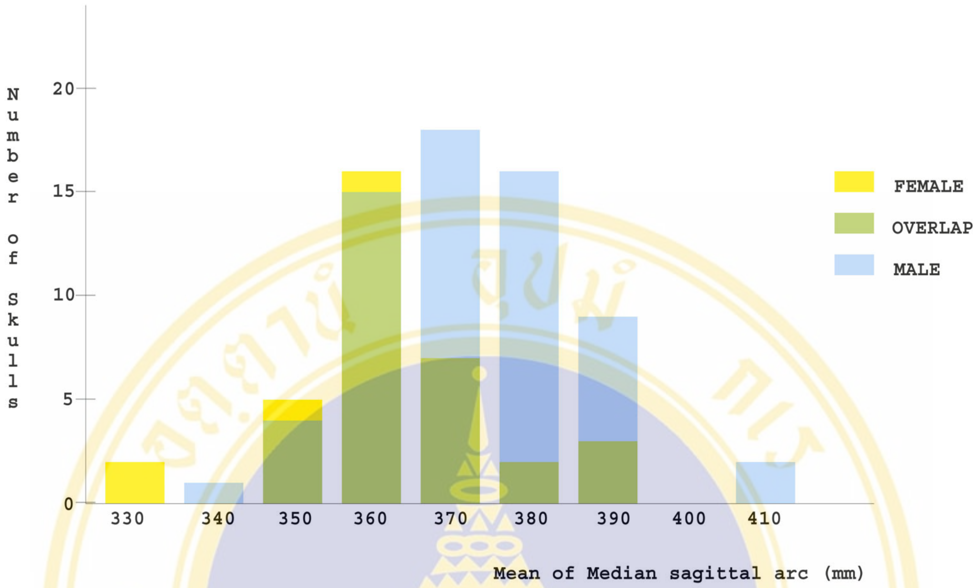

Figure 13. Distribution of Median sagittal arc (M25)

Table 7 Comparison of Single component of median sagittal curve in males and females.

Measurements	Sex	n	Mean	SD	Min, Max	Difference (M-F)		
						Mean	**95% CI**	**p-value**
M26 (Nasion-bregma arc)*	M	66	132.49	6.34	120, 150	4.39	1.70, 7.09	0.002
	F	35	128.09	6.78	110, 140			
M29 (Nasion-bregma cord)*	M	66	110.65	4.96	98.5, 125	3.69	1.56, 5.83	0.001
	F	35	106.96	5.51	94.0, 117			
M29/M26 (Sagittal-frontal index)	M	66	83.55	1.74	80.4, 89.2	0.02	-0.73, 0.76	0.963
	F	35	83.53	1.89	80.0, 89.2			

* $p < 0.05$

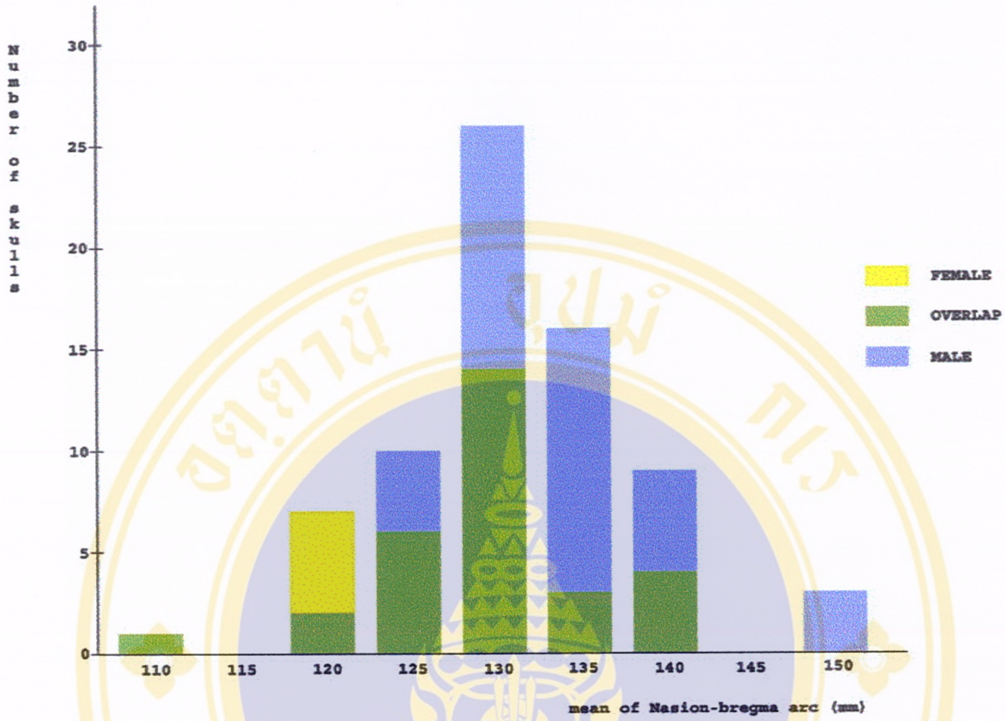

Figure 14. Distribution of Nasion-bregma arc (M26)

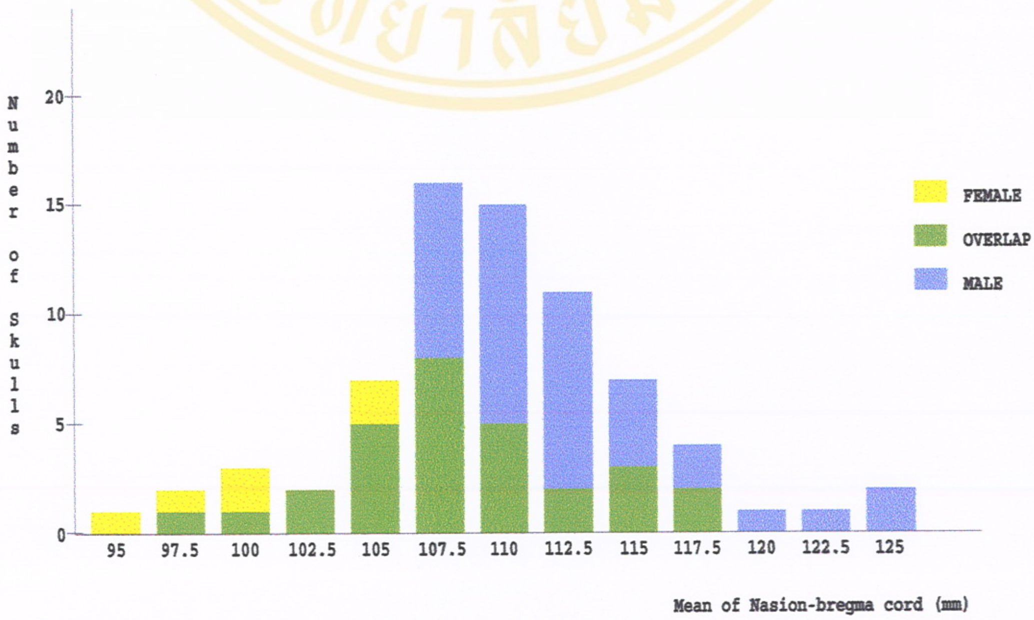

Figure 15. Distribution of Nasion-bregma cord (M29)

Table 8 Comparison of Length, Breadth and Height of face in males and females

Measurements	Sex	N	Mean	SD	Min, Max	Difference (M-F) Mean	95% CI	p-value
M40 (Facial length)*	M	66	95.78	5.60	85, 110	6.01	3.63, 8.39	0.001
	F	35	89.77	6.01	78, 101			
M42 (Lower facial length)*	M	66	109.72	7.64	91.5, 130	5.42	2.08, 8.76	0.002
	F	35	104.30	8.77	86.5, 130			
M44 (Biorbital breadth)*	M	66	96.79	4.07	88, 105	4.70	3.08, 6.32	<0.001
	F	35	92.09	3.56	85, 102			
M45 (Bizygomatic breadth)*	M	66	136.33	5.75	125, 150	8.78	6.44, 11.11	<0.001
	F	35	127.54	5.39	115, 140			
M47 (Facial height)*	M	66	108.55	16.19	72, 136	10.00	3.50, 16.50	0.003
	F	35	98.54	14.61	66, 123.5			
M48 (Upper facial height)*	M	66	67.12	4.94	55, 78	4.98	2.85, 7.10	<0.001
	F	35	62.14	5.44	48, 71.5			
M47/M45 (Facial index)	M	66	79.76	12.21	52.1, 99.6	2.41	-2.56, 7.39	0.338
	F	35	77.35	11.56	52.8, 92.3			

* $p < 0.05$

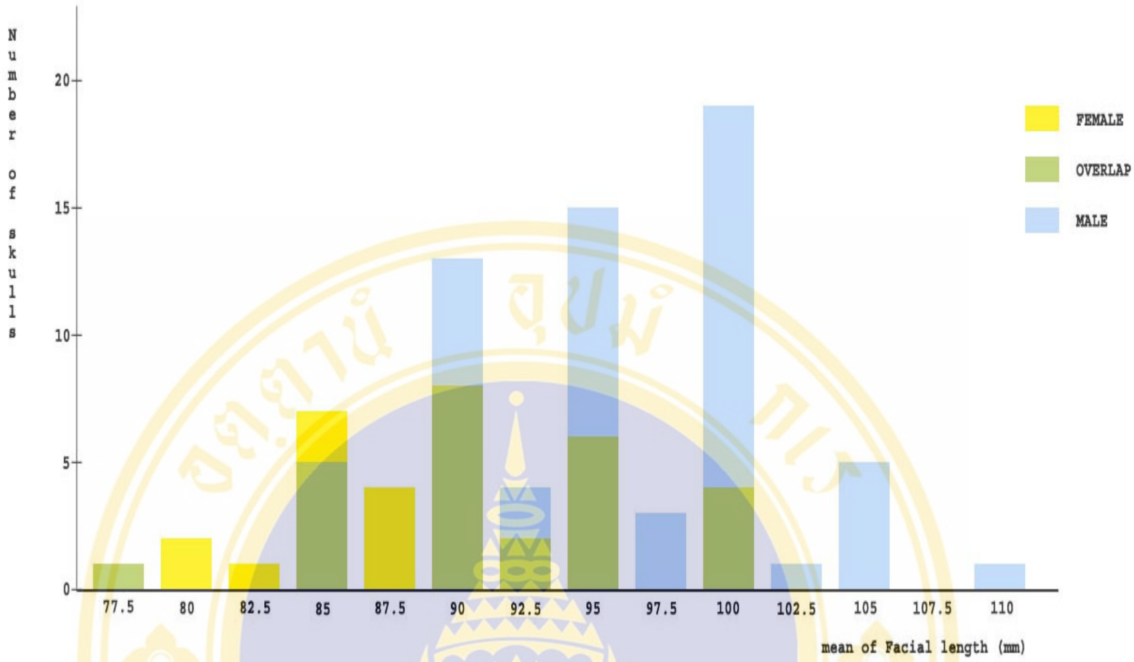

Figure 16. Distribution of Facial length (M40)

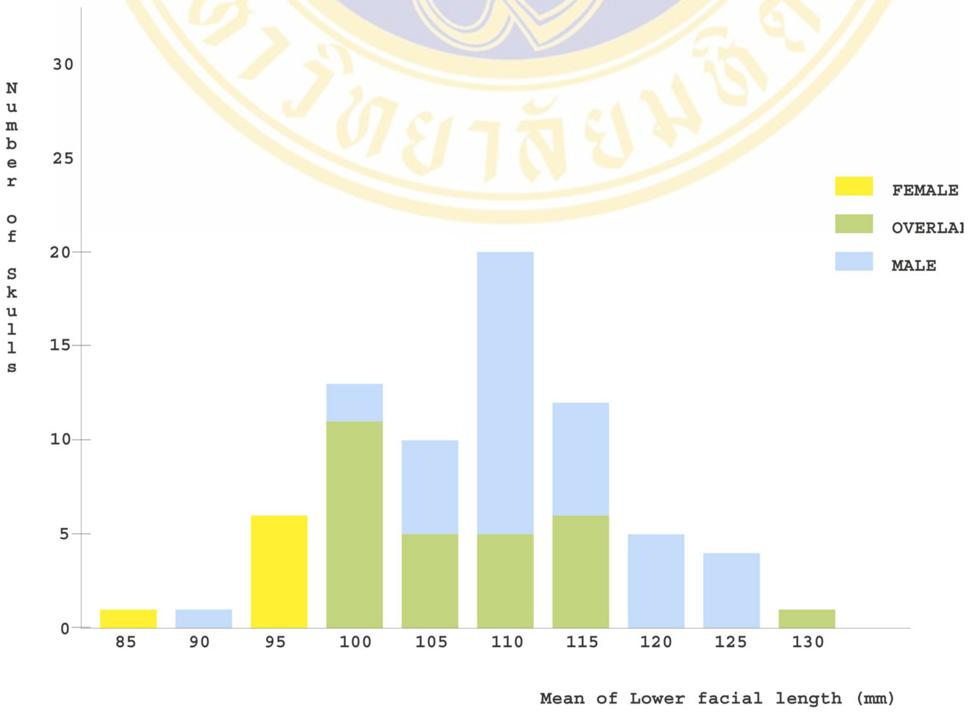

Figure 17. Distribution of Lower facial length (M42)

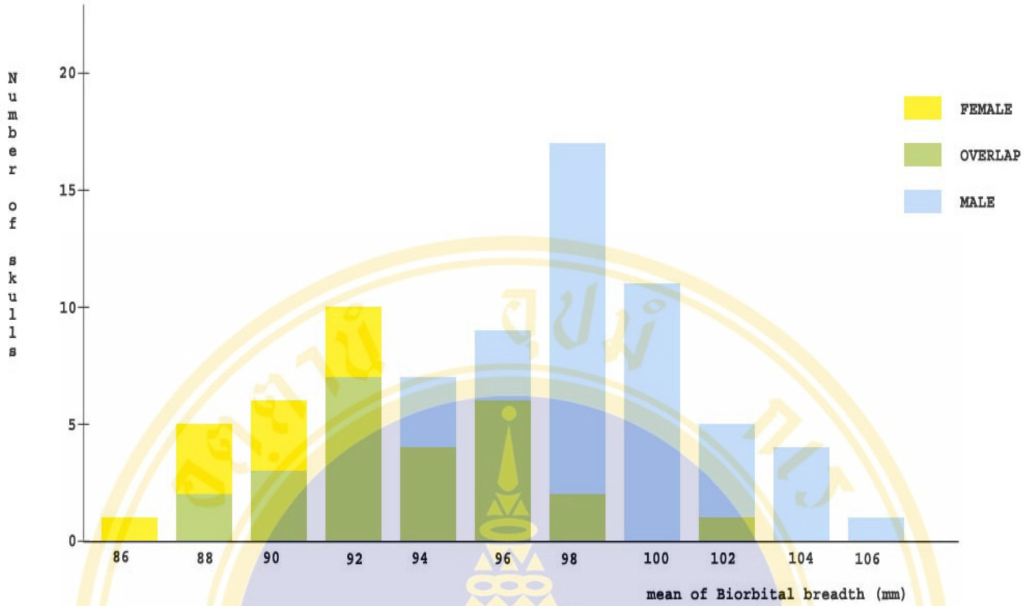

Figure 18. Distribution of Biorbital breadth (M44)

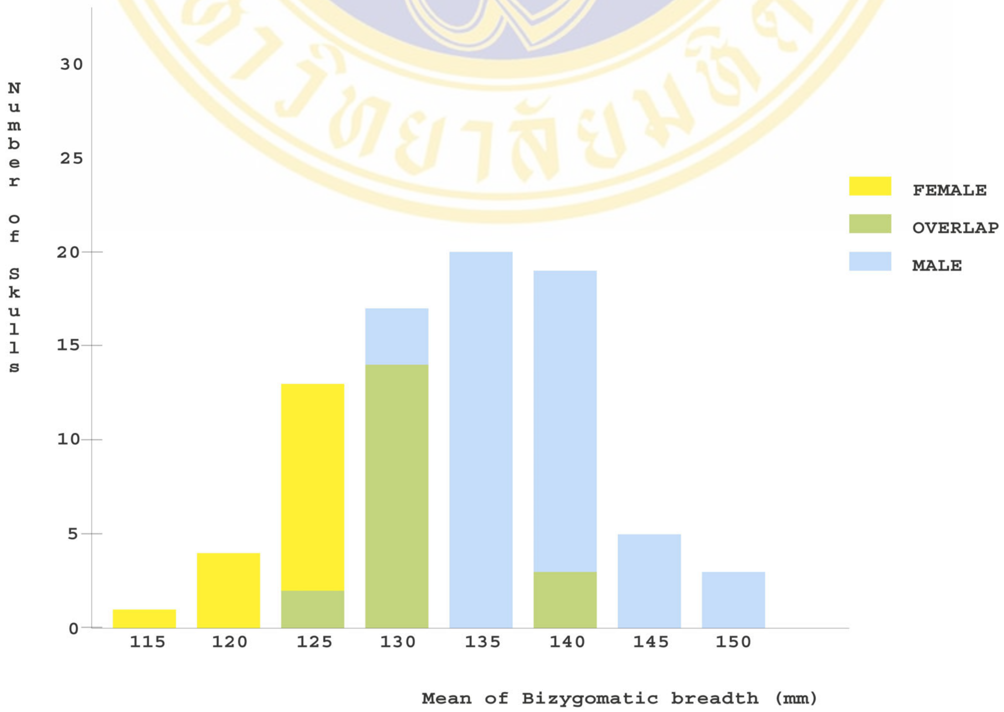

Figure 19. Distribution of Bizygomatic breadth (M45)

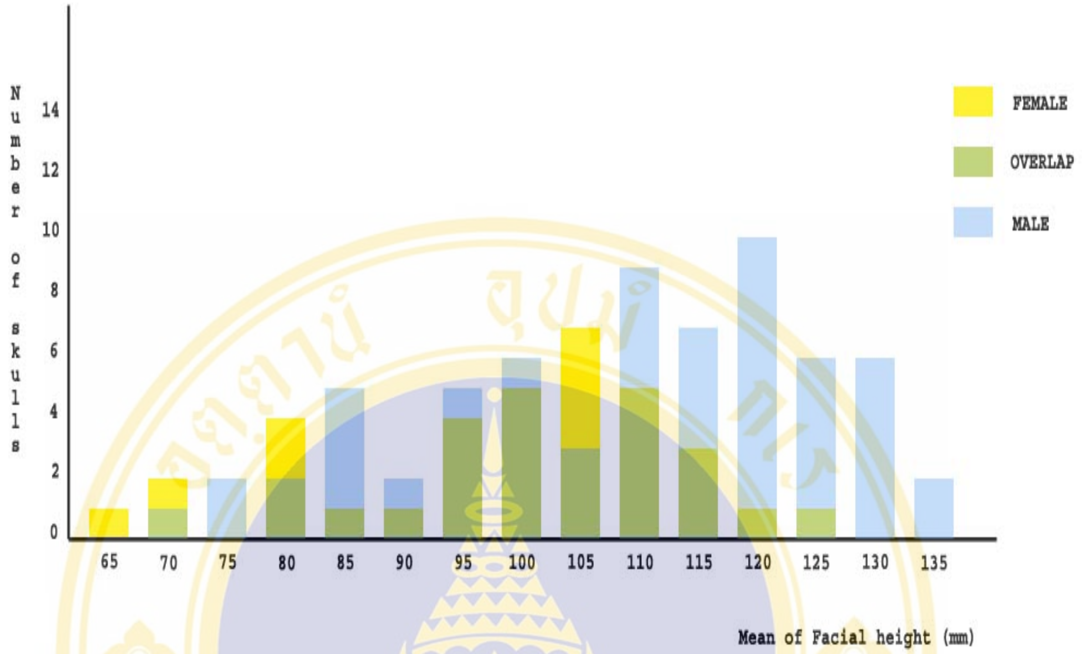

Figure 20. Distribution of Facial height (M47)

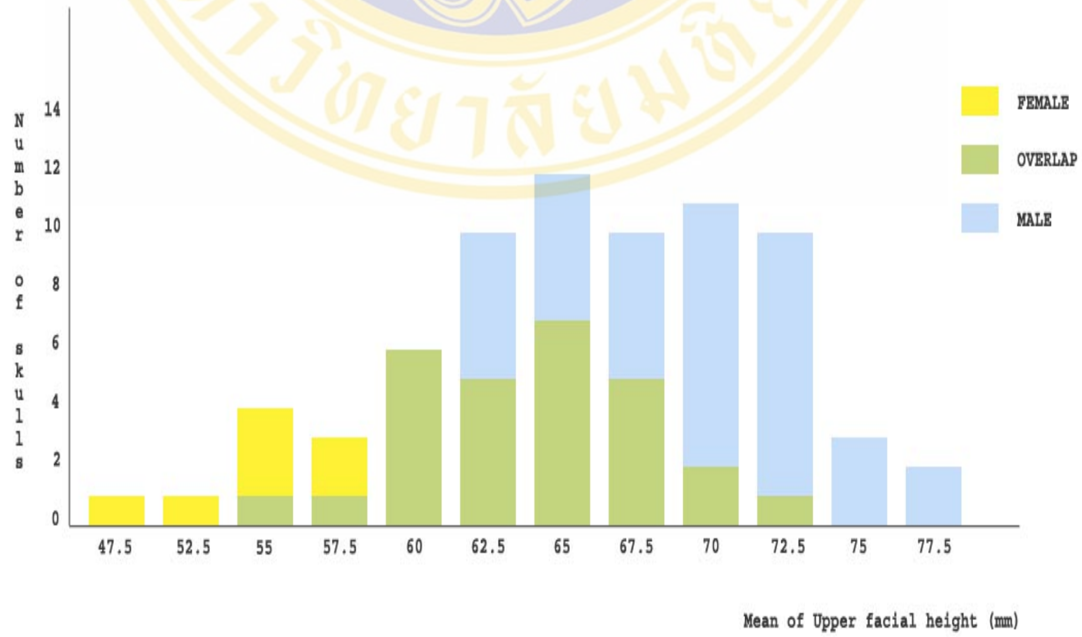

Figure 21. Distribution of Upper facial height (M48)

Table 9 Comparison of Orbit, Interorbit in males and females.

Measurements	Sex	n	Mean	SD	Min, Max	Difference (M-F)		
						Mean	95% CI	p-value
Orbit								
M51 (Orbital breadth)*	M	66	40.10	1.89	36, 44.0	2.01	1.17, 2.85	<0.001
	F	35	38.09	2.25	32, 41.5			
M52 (Orbital height)	M	66	33.44	2.33	30, 41.0	0.55	-0.41, 1.51	0.255
	F	35	32.89	2.28	29, 39.5			
M52/M51 (Orbital index)*	M	66	83.50	6.00	72.3, 96.3	-3.11	-5.86, -0.37	0.027
	F	35	86.61	7.65	74.1, 112.9			
Interorbit								
M50 (Anterior interorbital breadth)*	M	66	15.30	2.43	10, 22	1.25	0.30, 2.20	0.010
	F	35	14.04	2.01	10, 19			
M49 (Posterior interorbital breadth)*	M	66	21.20	2.41	15, 26	1.75	0.82, 2.69	<0.001
	F	35	19.44	1.90	16, 24			

* $p < 0.05$

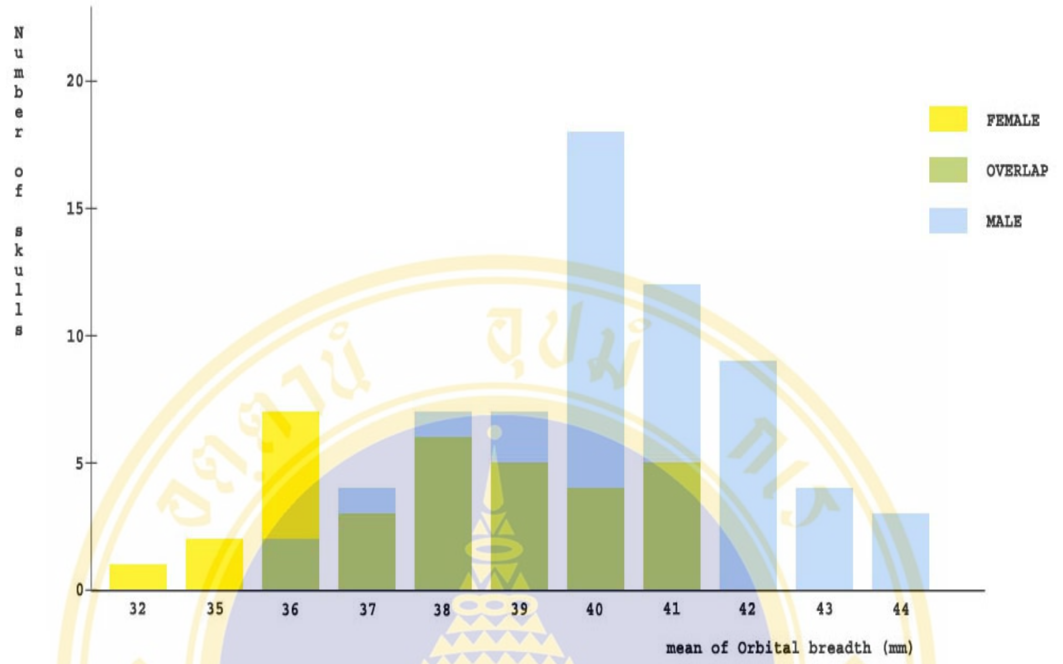

Figure 22. Distribution of Orbital breadth (M51)

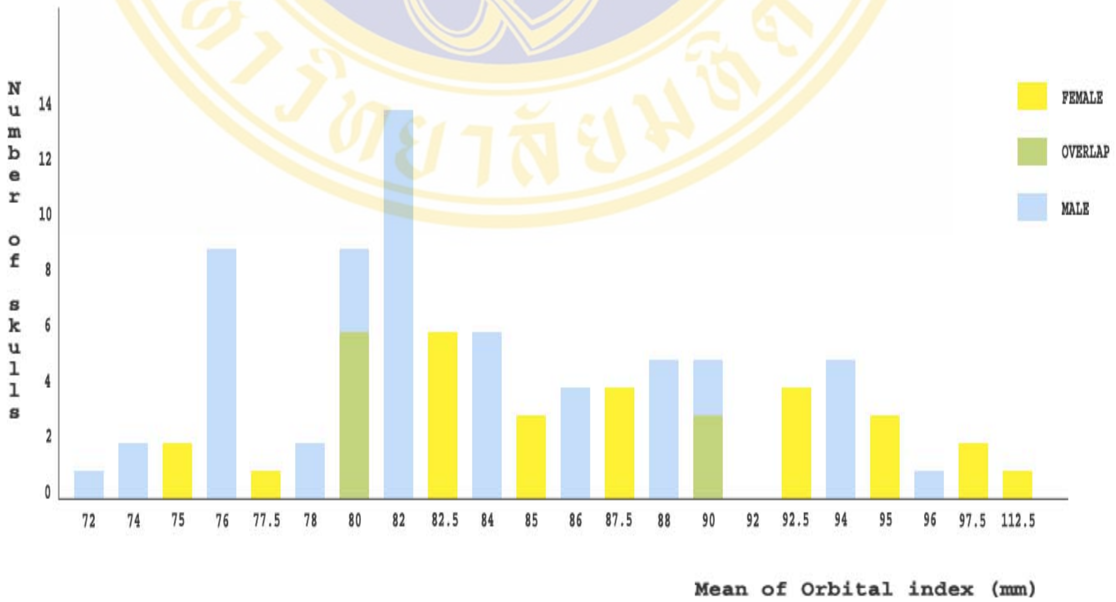

Figure 23. Distribution of Orbital index (M52/M51)

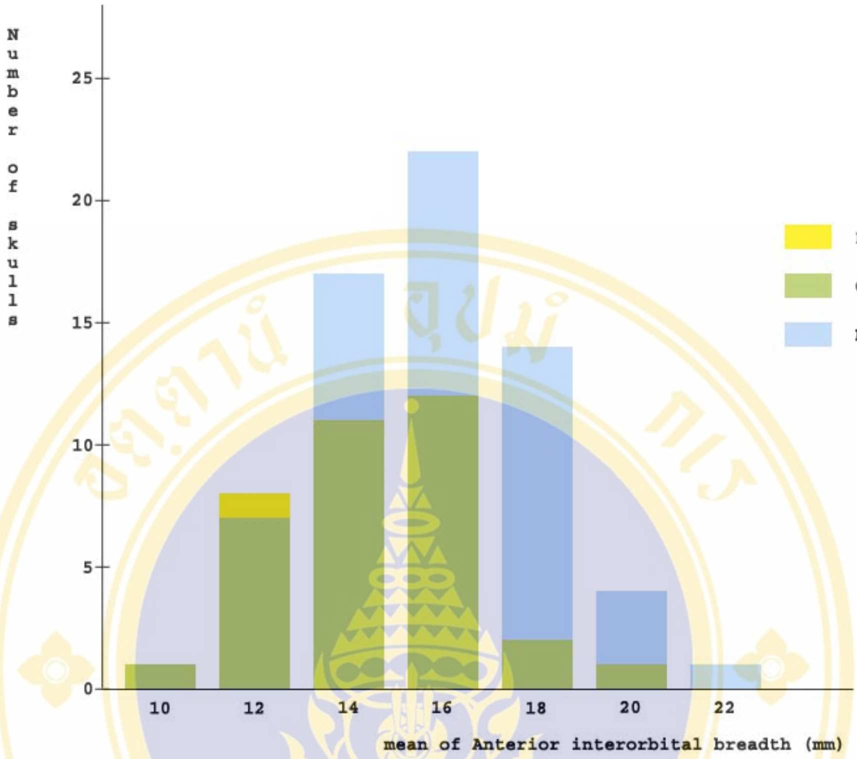

Figure 24. Distribution of Anterior interorbital breadth (M50)

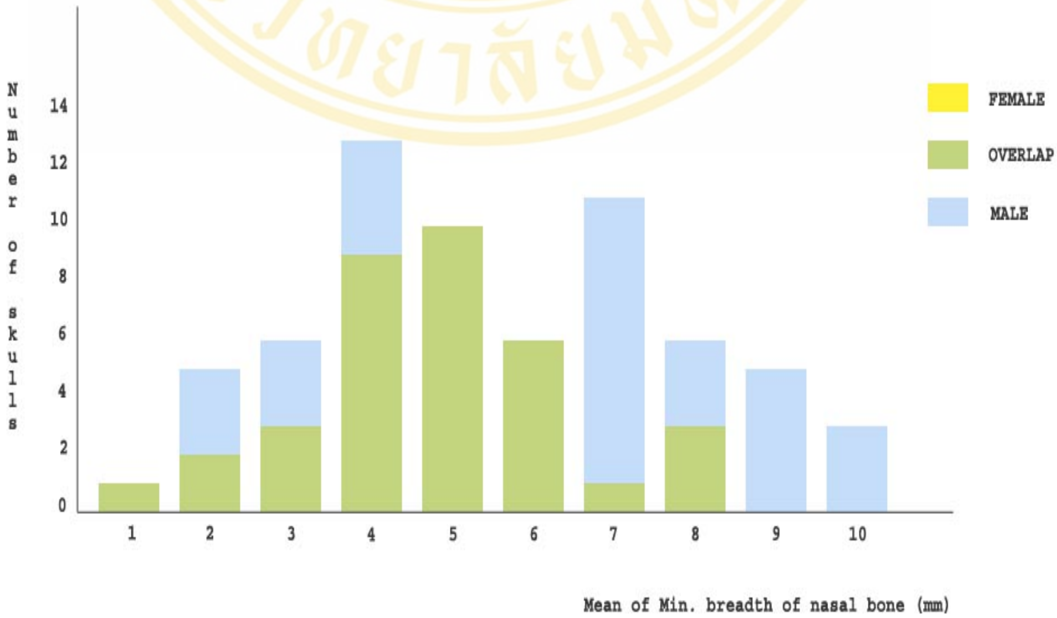

Figure 25. Distribution of Posterior interorbital breadth (M49)

Table 10 Comparison of Nose and Mandible in males and females

Measurements	Sex	n	Mean	SD	Min, Max	Difference (M-F)		
						Mean	95% CI	p-value
Nose								
M57 (Min. breadth of nasal bone)*	M	66	5.46	2.26	0.5, 10	0.83	0.06, 1.61	0.035
	F	35	4.63	1.61	1.0, 8			
M57.1 (Max. breadth of nasal bone)	M	65	14.12	1.96	7.5, 18	0.59	-0.21, 1.39	0.146
	F	35	13.53	1.85	9.0, 18			
Mandible								
M65 (Bicondylar breadth)*	M	66	119.95	5.84	107.0, 135	5.55	3.08, 8.02	<0.001
	F	35	114.40	6.15	104.5, 127			
M66 (Bigonial breadth)*	M	66	97.49	5.92	83.0, 111.5	6.71	4.39, 9.03	<0.001
	F	35	90.79	4.91	82.5, 105.0			
M70 (Height of mandibular ramus)*	M	66	63.11	6.94	47, 78.5	6.26	3.54, 8.98	<0.001
	F	35	56.86	5.74	43, 69.0			

Measurements	Sex	n	Mean	SD	Min, Max	Difference (M-F)		
						Mean	**95% CI**	**p-value**
M71 (Breadth of mandibular ramus)*	M	66	30.40	3.11	25, 38	2.69	1.30, 4.08	<0.001
	F	35	27.71	3.78	20, 36			
M79 (Mandibular angle)	M	66	119.83	6.89	105, 139	-2.15	-5.20, 0.90	0.166
	F	35	121.97	8.16	105, 138			
M71/M70 (Mandibular ramus index)	M	66	48.63	6.34	32.9, 64.0	-0.24	-2.79, 2.32	0.855
	F	35	48.86	5.80	39.5, 65.4			
Ratio of mandible to face								
M66/M45 (Jugo-mandibular index)	M	66	71.56	4.14	64.4, 79.6	0.36	-1.09, 1.80	0.624
	F	35	71.20	3.07	65.4, 80.0			

* $p < 0.05$

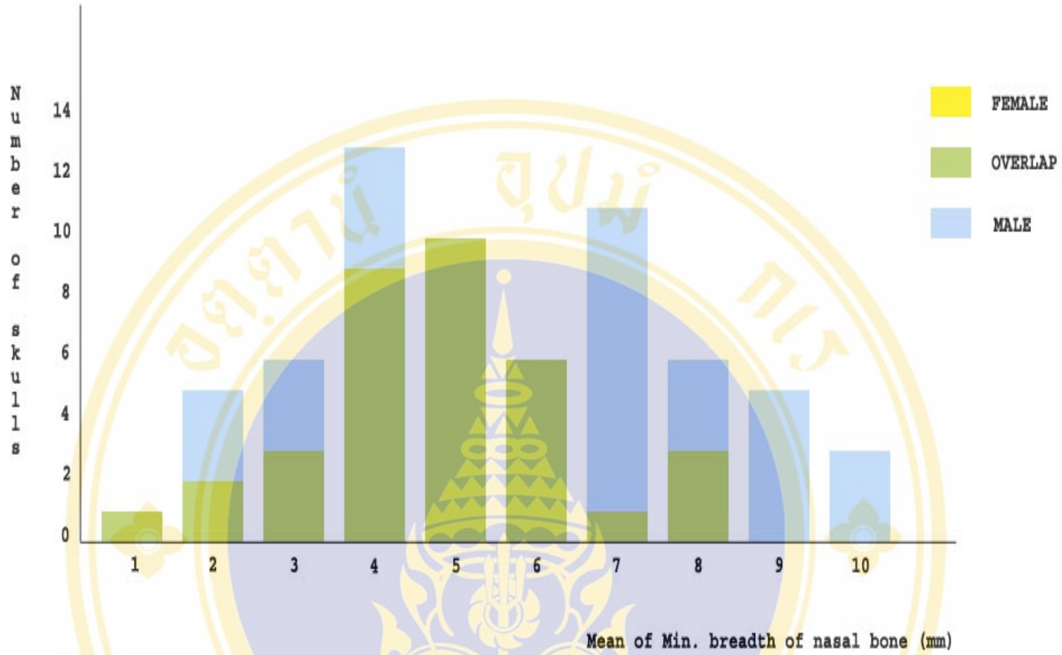

Figure 26. Distribution of Min. breadth of nasal bone (M57)

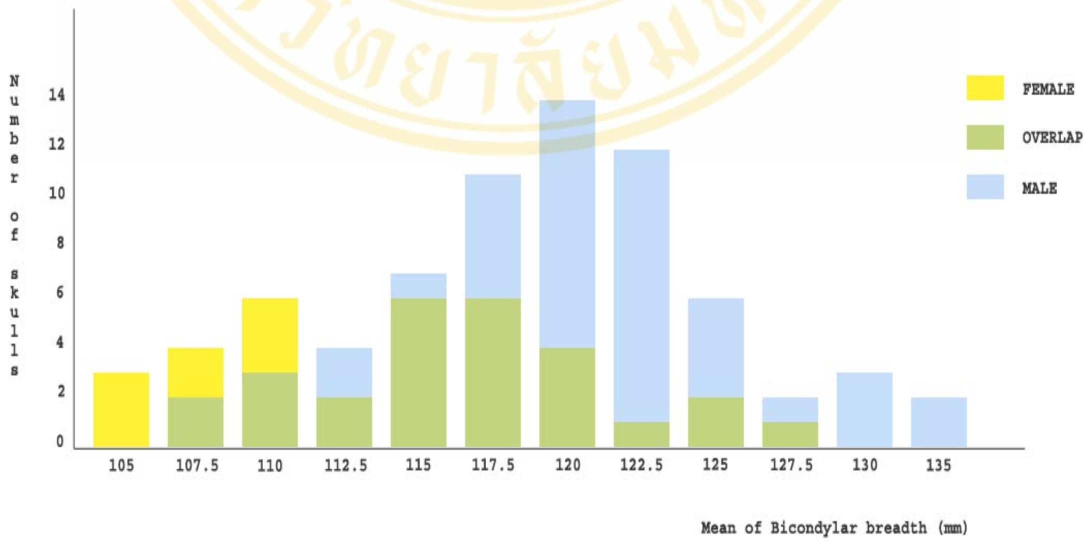

Figure 27. Distribution of Bicondylar breadth (M65)

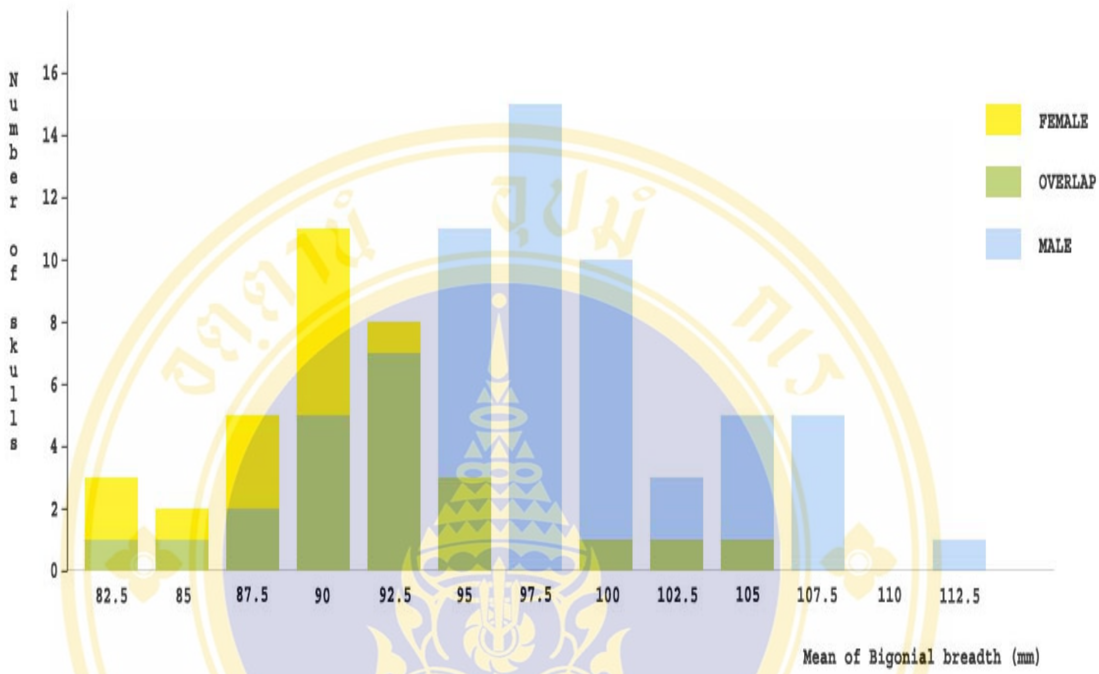

Figure 28. Distribution of Bigonial breadth (M66)

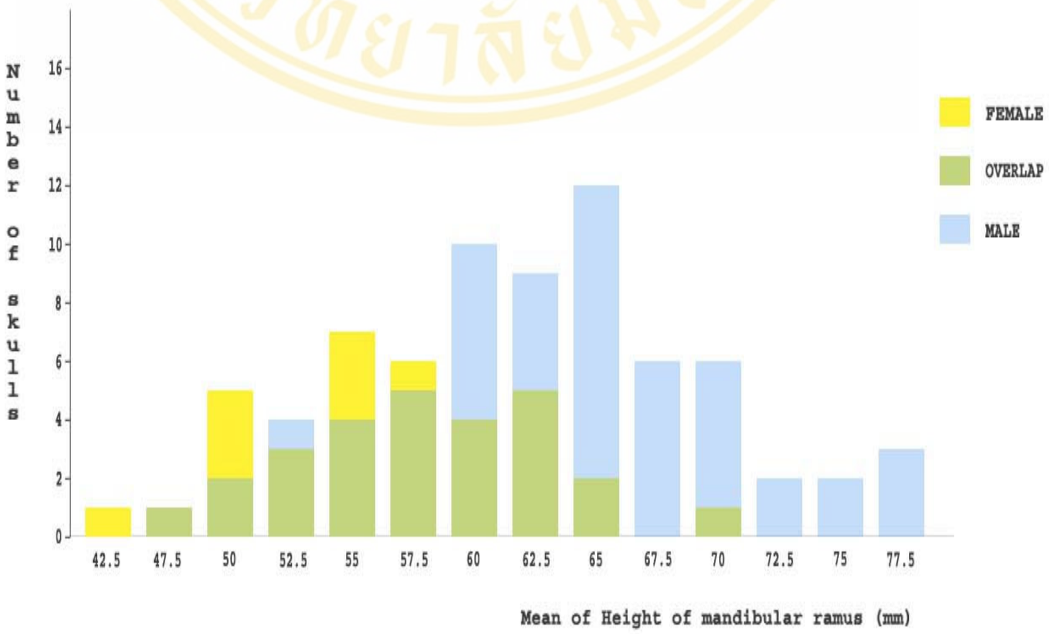

Figure 29. Distribution of Height of mandibular ramus (M70)

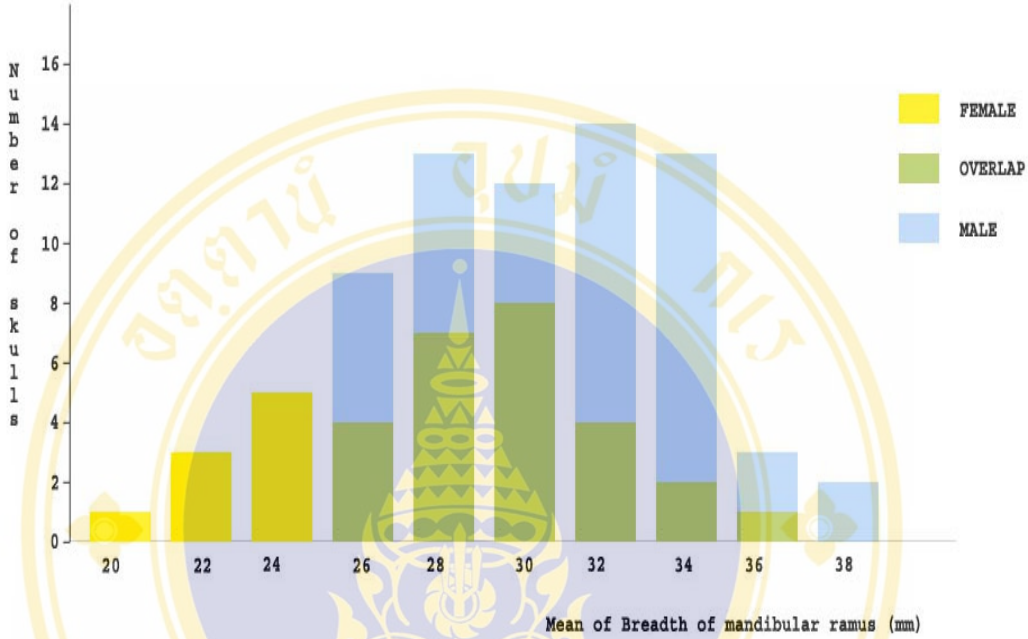

Figure 30. Distribution of Breadth of mandibular ramus (M71)

Table 11 Comparison the Ratio of neuro- to viscero-cranium in males and females.

Measurements	Sex	n	Mean	SD	Min, Max	Difference (M-F)		
						Mean	95% CI	p-value
M40/M5 (Alveolar index)	M	66	94.16	5.04	85.0, 105.3	-0.90	-3.28, 1.48	0.456
	F	35	95.06	6.86	82.1, 111.1			
M9/M45 (Jugo-frontal index)	M	66	59.97	3.49	52.0, 71.4	-1.01	-2.49, 0.47	0.180
	F	35	60.97	3.72	53.9, 69.2			
M45/M8 (Cranio-facial index)*	M	65	93.55	3.75	86.2, 100.0	5.32	3.77, 6.87	<0.001
	F	35	88.23	3.67	80.0, 96.3			

* $p < 0.05$

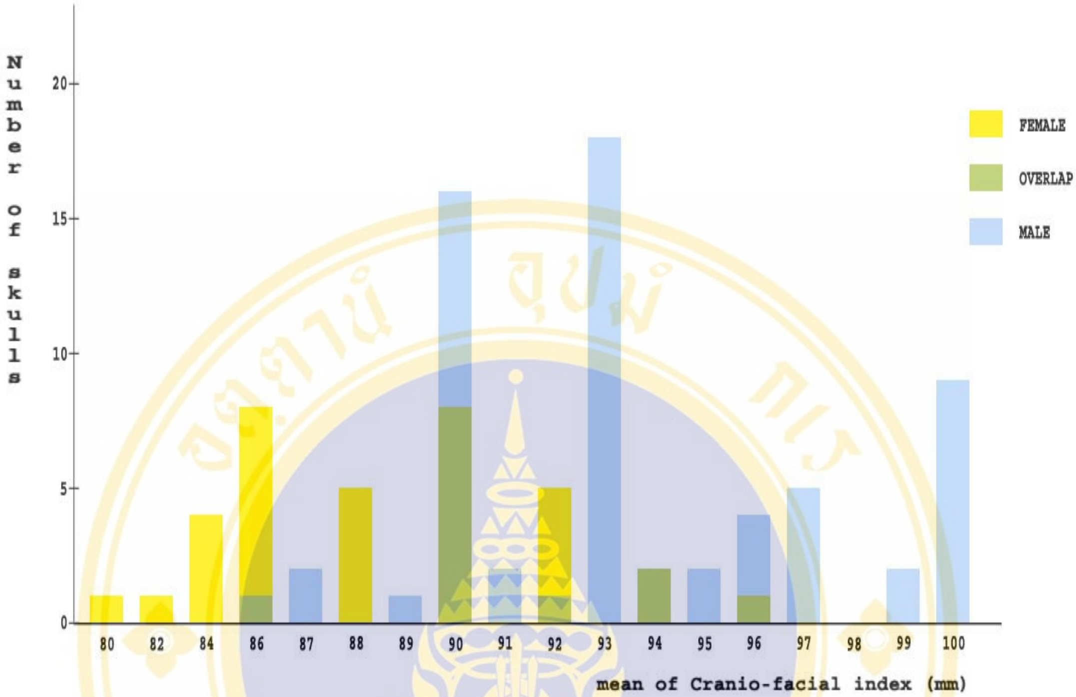

Figure 31. Distribution of Cranio-facial index (M45/M8)

Table 12 Results of multiple logistic regression analysis

Measurements	Coefficient (b)	p-value
Constant*	-52.566	< 0.001
Measurements		
Nasion-basion length (M5)*	0.278	0.010
Maximum breadth of the cranium (M8)*	-0.193	0.014
Facial height (M40)*	0.134	0.041
Bizygomatic breadth of the face (M45)*	0.315	0.001

* $p < 0.05$

P = Probability of being male

$$= \frac{e^{Z}}{1 + e^{Z}}$$

1 – P = Probability of being female

where $e = 2.718$

$$\mathbf{Z = -52.566 + 0.278\,M5 - 0.193\,M8 + 0.134\,M40 + 0.315\,M45}$$

CHAPTER VI
DISCUSSION

The present study deals with the accuracy for sex determination of Thai skulls by using cranioscopy and craniometry. It is known that craniums show sexual dimorphism.

Cranioscopy: Although, the sex of unidentified skulls is not always easily and correctly determined by the general medical examiner with no formal training in forensic anthropology, I, a new comer, could predict the sex determination with a very high accuracy of 95.5% for males and 82.9% for females respectively and the overall accuracy of 91.1% by using Krogman's method which is based on 14 characteristics of skull. Sometimes the diagnostic procedure may be extremely complicated when handling fragmented bones. Thus, the present study developed two methods; the modified Krogman's cranioscopy traits by grading and the modified Krogman's cranioscopy traits by measurement. Both methods may be useful in the sex determination of skull remains under the above-mentioned conditions as well as when an expert in forensic anthropology or a crime laboratory is not available.

Craniometry was used landmarks and bone measurements in terms of physical anthropology according to Martin (1928) standard method which was modified by Jorgensen's method (1968). However, we used only some remarkable measurements (30 measurements). All these measurements listed in Tables 4 -11 showed significant sex differences of the means except for 4 measurements: maximum breath of cranium, mandibular angle, and orbital height, max. breadth of nasal bone. As the results, we have found difference of the skull from the gender. Briefly, the skull of a male was larger and higher than that of a female. Although these 26 measurements showed a high degree of significance of the means, they had overlapping range which can not be definitely sexed by craniometry. Therefore, the accuracy of sex determination by craniometry was less than that of cranioscopy. Then, we also used 15 cranial indices to evaluate the sex determination. All these indices listed in Tables 4 -11 showed significant sex differences of the means only 5 indices. So, this results were remarked the less accuracy of sex determination by using craniometry.

Multiple Logistic Regression Analysis can highly predict gender by using 4 measurements: nasion-basion length (M5), maximum breadth of the cranium (M8), facial length (M40), and bizygomatic breadth of the face (M45). It could correctly predict 82.9% (29/35) in females and 92.3% (60/65) in males respectively. The overall accuracy was 89% (89/100).

$$\mathbf{Z = -52.566 + 0.278\ M5 - 0.193\ M8 + 0.134\ M40 + 0.315\ M45}$$

$$P = \text{Probability of being male}$$

$$= \frac{e^{Z}}{1 + e^{Z}}$$

$$1 - P = \text{Probability of being female}$$

e = constant value (2.718)

For testing the accuracy of this formula (Appendix C), 32 unknown skulls were measured 4 measurements (M5, M8, M40, M45), then were calculated by using this formula. It could correctly predict 41.67% (5/12) in females and 90% (18/20) in males respectively. The overall accuracy was 71.88% (23/32). This statistical method is less accuracy in sex determination of the unknown individual skull than cranioscopy's method.

CHAPTER VII
CONCLUSION

The present study deals with the accuracy for sex determination of Thai skulls by using cranioscopy and craniometry. One hundred and one adult Thai dried skulls (66 males and 35 females) ranged in age from 18 to 86 years were used in this study. The mean age was 51.1 years. In general, sex can be appraised morphologically (cranioscopy) as well as metrically (craniometry).

1. **Cranioscopy**

Krogman's Cranioscopy which is based on 14 characteristics of skull had a very high accuracy of 95.5% for males and 82.9% for females respectively and the overall accuracy of 91.1%.

Modified Krogman's Cranioscopy Trait by Grading is based on 3 characteristics of skull, namely supraorbital torus, glabella, and external occipital protuberance. Male had larger supraorbital torus, rougher glabella region and external occipital protuberance than females.

Modified Krogman's Cranioscopy Trait by Measurement, males had wider base and higher of mastoid process, longer and wider of occipital condyles than females.

2. **Craniometry**

Length, breadth and height of cranium, males had longer length (M1), higher basion-bregma height (M7), wider minimum (M9) and maximum frontal (M10), higher transverse fronto-parietal index (M9/M8), lower cranial index (M8/M1), and higher breadth-height index (M7/M8) than females.

Basis cranii, males had longer nasal-basion (M5), longer and wider foramen magnum than females.

Circumference and curve of skull, males had circumference, transverse arc and median sagittal arc longer than females.

Median sagittal curve, males had longer nasion-bregma arc (M26) and nasionbregma cord (M29) than females.

Length, breadth and height of face, males had the following measurements significantly higher than females: face length (M40) longer, lower facial length (M42) longer, biorbital breadth (M44) wider, bizygomatic breadth (M45) wider, face height (M47) higher and upper face height (M48) higher.

Orbit, Interorbit, males had significantly wider orbit (M51), lower ratio of height to breadth of orbit, wider anterior and posterior interorbital breadth than females.

Nose and Mandible, males had wider minimum breadth (M57) and maximum breadth of nasal bone (M57.I), wider bicondylar breadth (M65) and bigonial breadth (M66), higher height (M70) and wider breadth (M71) of mandibular ramus than females.

Ratio of neuro- to viscero- cranium, the cranio-facial index for males was higher than females.

3. Multiple Logistic Regression Analysis can highly predict gender by using 4 measurements: nasion-basion length (M5), maximum breadth of the cranium (M8), facial length (M40), and bizygomatic breadth of the face (M45). It could correctly predict 82.9% (29/35) of females and 92.3% (60/65) of males respectively. The overall accuracy was 89% (89/100). This formula was

$$\mathbf{Z = -52.566 + 0.278\,M5 - 0.193\,M8 + 0.134\,M40 + 0.315\,M45}$$

P = Probability of being male, 1 – P = Probability of being female

$$= \frac{e^{Z}}{1 + e^{Z}}$$

e (constant value) = 2.718

For testing the accuracy of this formula, 32 unknown skulls (Appendix C) were measured 4 measurements (M5, M8, M40, M45), then were calculated by using this formula. It could correctly predict 41.67% (5/12) of females and 90% (18/20) of males respectively. The overall accuracy was 71.88% (23/32). Therefore, the cranioscopy study which is based on 14 external traits according to Krogman's suggestion is the best method for sex determination of individual unknown skulls. It has been claimed that morphology can give a better indicator of sex. Moreover, if we used cranioscopy with craniometry together may predict gender more high accuracy.

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APPENDIX

APPENDIX A

Skull's Data Report

Date ……………………………S …………………………Sex…………..Age……

Sex determination by Cranioscopy: Grading cranioscopy trait

1. supraorbital torus
2. glabella region
3. external occipital protuberance

Measurement of cranioscopy trait

1. breadth of the base of mastoid process
2. height of mastoid process
3. length of occipital condyle (Lt) (M80)
4. breadth of occipital condyle (Lt) (M 81)

Craniometry …………….. mm.

Measurements

M 1	Maximum length ………………….	M 45	Bizygomatic breadth……………
M 5	Nasion-Basion length …………….	M 47	Facial height ……………………
M 7	Basion – bregma-height …………	M 48	Upper facial height ……………...
M 8	Maximun breadth …………………	M 49	Post. Interorbital breadth ……….
M 9	Minimum frontal breadth…………	M 50	Ant. Interorbital breadth………..
M 10	Maximum frontal breadth ………..	M 51	Orbital breadth (Lt) …………….
M 16	Breadth of foramen magnum ……	M 52	Orbit height (Lt)…………………
M 17	Length of foramen magnum ……	M 57	Minimum breadth of nasal B ……
M 23	Circumference ……………………	M 57(I)	Maximum breadth of nasal B …..

M 24 Transversal arch …………………
M 25 Median sagittal arch …………….
M 26 Nasion – bregma arch …………
M 29 Nasion – bregma cord …………
M 40 Facial length ……………………..
M 42 Lower facial L. …………………..
M 44 Biorbital breadth ………………..

Mandible
M 65 Bicondylar breadth ………………
M 66 Bigonial breadth ……………..
M 70 Height of mandibular ramus…
M 71 Breadth of mandibular ramus ..
M 79 Mandibular angle ……………..

Index

I 1 Cranial index = $\frac{(M\ 8) \times 100}{(M\ 1)}$ = ……………….

I 2 Length-height index = $\frac{(M\ 7) \times 100}{(M\ 1)}$ = ……………….

I 3 Breadth-height index = $\frac{(M\ 7) \times 100}{(M\ 8)}$ = ……………….

I 4 Transverse frontal index = $\frac{(M9\ ) \times 100}{(M10)}$ = ……………

I 5 Transverse fronto-parietal index = $\frac{(M\ 9) \times 100}{(M\ 8)}$ = ……………

I 7a Sagittal frontal index = $\frac{(M\ 29) \times 100}{(M\ 26)}$ =…………………

I 11 Foramen magnum length-breadth index = $\frac{(M\ 16) \times 100}{(M\ 7)}$ =…………..

I 12 Facial index $= \frac{(M\ 47) \times 100}{(M\ 45)} =$ ……………………

I 15 Jugo-mandibular index $= \frac{(M\ 66) \times 100}{(M\ 45)} =$ …………

I 16 Alveolar index $= \frac{(M\ 40) \times 100}{(M\ 5)} =$…………..

I 18 Jugo-frontal index $= \frac{(M\ 9) \times 100}{(M\ 45)} =$ …………………..

I 19 Transverse cranio-facial index $= \frac{(M\ 45) \times 100}{M\ 8)} =$…………..

I 20 Orbital index $= \frac{(M\ 52) \times 100}{(M\ 51)} =$ …………………..

I 26 Ramus index $= \frac{(M\ 71) \times 100}{(M\ 70)} =$ ………………………

I 27 Condylar index $= \frac{(M\ 81) \times 100}{(M\ 80)} =$ ……………………

APPENDIX B

ID	SEX	AGE	SUPRAOR	GLABELLA	EX_OCCI	SPINOUS	B_MASTOI	H_MASTOI
504	1	48	2	3	2	1	22.5	14.0
517	1	40	3	3	3	1	19.0	14.0
540	1	72	1	3	3	1	23.0	21.0
544	1	.	1	3	3	1	26.5	21.5
522	1	60	1	3	2	1	20.0	15.0
552	1	53	1	2	3	1	25.0	12.5
556	2	.	0	0	1	1	22.0	18.0
569	2	18	0	0	1	1	19.0	14.0
576	1	.	1	2	3	1	20.0	16.0
581	1	64	3	3	3	1	25.0	17.0
595	1	86	2	3	3	1	24.0	19.0
602	2	53	0	0	0	1	26.0	17.0
603	2	39	0	0	1	1	24.0	15.0
607	1	.	2	3	2	1	31.0	26.0
613	2	46	0	0	0	1	24.5	16.0
629	2	.	0	0	1	1	11.5	6.0
632	2	68	3	3	2	1	20.5	10.0
638	1	.	1	2	1	1	22.5	17.5
641	2	77	1	0	0	1	15.0	12.0
656	2	43	0	0	1	1	21.0	12.0
658	2	72	0	1	0	1	14.0	10.0
660	1	43	0	1	1	1	28.0	21.0
682	1	.	2	3	3	1	22.0	21.5
684	2	64	2	2	3	1	21.5	15.0
693	1	61	2	3	3	1	26.0	15.0
715	1	71	2	3	3	1	31.0	23.0
717	2	70	0	0	1	1	31.0	22.5
719	1	42	0	0	1	1	22.0	11.0
731	1	80	1	3	2	1	21.0	11.5
741	1	67	2	3	3	1	29.0	24.5
744	2	20	0	0	1	1	18.5	11.5
746	1	80	2	3	3	1	29.0	19.0
748	1	22	2	3	2	1	33.0	22.5
753	2	50	0	1	1	1	19.0	15.0
759	1	26	3	3	2	1	32.0	25.5
762	1	42	3	3	3	1	31.5	26.0
765	2	74	1	1	1	1	16.5	12.0
767	1	49	1	1	1	1	21.0	23.0
769	1	38	3	3	2	1	22.0	14.0
774	2	59	0	0	0	1	13.0	8.0
747	2	59	3	3	3	1	20.0	16.0
775	1	37	2	3	2	1	25.5	13.0

778	1	33	3	3	3	1	18.5	14.0
779	2	34	0	1	0	1	17.0	12.0
781	1	72	1	3	3	1	28.0	25.0
801	1	73	3	3	3	1	25.0	15.0
805	1	74	2	3	3	1	19.0	15.0
809	1	39	2	3	2	1	27.0	20.0
810	1	66	1	2	2	1	23.0	14.5
811	1	39	3	3	2	1	20.0	15.0
814	2	.	0	0	0	1	18.0	13.0
824	2	47	1	1	1	1	21.0	16.0
835	1	79	3	3	3	1	38.0	24.0
842	1	.	2	3	3	1	21.5	15.5
843	2	34	0	0	0	1	21.0	17.0
849	1	37	2	2	2	1	32.0	25.0
854	1	28	2	3	2	1	22.5	24.5
867	2	73	1	0	1	1	18.5	11.5
870	1	62	3	3	3	1	18.0	14.5
857	1	50	2	2	3	1	23.5	13.5
875	1	50	2	3	3	1	21.0	18.0
883	1	34	3	3	1	1	16.5	10.0
887	2	51	0	0	1	1	14.0	12.0
893	1	67	1	3	3	1	21.0	11.0
895	1	50	0	1	1	1	17.0	14.0
898	1	44	1	1	1	1	21.0	13.0
899	1	43	3	3	3	1	31.0	23.5
902	1	28	3	3	.	1	26.0	18.0
904	2	26	0	1	1	1	19.0	14.0
906	2	49	0	0	1	1	13.0	11.5
908	2	78	1	1	2	1	18.0	16.0
909	1	55	2	3	2	1	16.0	8.5
911	1	64	3	3	3	1	35.0	28.5
913	2	55	0	0	1	1	17.0	11.0
914	1	55	2	3	3	1	23.0	18.0
922	1	.	3	3	3	1	25.0	13.5
923	1	.	3	3	3	1	28.0	26.0
925	2	83	1	0	0	1	21.5	14.0
927	1	49	1	3	3	1	23.0	16.5
928	1	65	1	3	2	1	15.0	12.0
929	1	24	3	3	3	1	28.0	27.0
930	1	36	2	3	3	1	21.0	14.5
931	2	76	1	2	1	1	18.0	10.5
932	1	46	3	3	3	1	18.0	12.0
933	1	75	2	2	3	1	17.0	13.5
934	1	37	3	3	3	1	19.0	18.0
936	2	48	0	0	0	1	18.0	14.0
938	1	30	3	3	2	1	25.5	22.0
939	1	40	3	3	2	1	20.5	14.0

940	1	22	1	3	3	1	18.0	10.0
941	2	41	0	0	0	1	17.5	14.5
942	1	37	2	3	3	1	19.0	15.0
943	1	41	1	3	2	1	25.0	15.0
944	1	45	3	3	3	1	20.5	11.0
945	1	29	2	3	1	1	18.5	14.0
947	2	47	0	0	1	1	24.0	19.0
949	2	36	0	1	1	1	23.0	18.0
950	2	27	0	0	1	1	21.0	10.0
953	1	49	2	2	3	1	26.0	20.0
966	2	60	0	0	0	1	19.0	11.5

ID	L_OCCI	B_OCCI	M1	M5	M7	M8	M9	M10	M16
504	25.5	10.0	180.0	95.0	135.0	145.0	70.0	125.0	26.5
517	23.0	8.0	185.0	100.0	150.0	140.0	85.0	125.0	26.5
540	19.0	10.0	175.0	100.0	140.0	150.0	90.0	130.0	32.0
544	20.0	12.0	170.0	100.0	145.0	150.0	90.0	115.0	30.0
522	22.5	10.0	170.0	110.0	145.0	145.0	75.0	120.0	28.0
552	19.0	11.5	180.0	95.0	135.0	140.0	75.0	115.0	24.5
556	20.0	13.0	170.0	100.0	140.0	150.0	90.0	125.0	30.0
569	24.0	7.0	170.0	95.0	130.0	145.0	85.0	115.0	21.0
576	20.5	11.0	170.0	95.0	135.0	140.0	80.0	115.0	26.0
581	26.0	11.0	165.0	100.0	140.0	150.0	85.0	130.0	29.0
595	19.0	14.0	180.0	95.0	140.0	140.0	85.0	120.0	29.0
602	24.0	9.0	170.0	95.0	140.0	145.0	78.0	120.0	25.0
603	22.5	10.0	160.0	95.0	145.0	148.0	75.0	120.0	25.0
607	22.0	11.0	170.0	100.0	140.0	150.0	80.0	130.0	24.5
613	18.0	10.0	165.0	95.0	130.0	130.0	75.0	110.0	22.0
629	21.5	10.0	165.0	95.0	140.0	150.0	75.0	115.0	25.0
632	27.0	9.0	175.0	105.0	140.0	145.0	77.0	120.0	28.0
638	21.0	8.0	185.0	100.0	145.0	150.0	75.0	130.0	27.0
641	17.0	11.0	160.0	90.0	140.0	148.0	70.0	120.0	23.5
656	21.0	12.5	170.0	95.0	130.0	150.0	75.0	125.0	25.0
658	19.5	12.5	165.0	95.0	135.0	140.0	75.0	115.0	28.0
660	21.0	13.0	170.0	105.0	135.0	147.0	82.0	125.0	31.0
682	23.5	9.0	175.0	105.0	137.0	155.0	80.0	122.0	29.0
684	24.5	10.0	180.0	105.0	140.0	150.0	85.0	130.0	24.0
693	22.0	11.0	180.0	100.0	140.0	155.0	85.0	125.0	27.0
715	27.0	9.0	175.0	100.0	145.0	150.0	78.0	128.0	29.0
717	21.5	9.0	180.0	100.0	140.0	145.0	80.0	125.0	26.0
719	19.0	8.0	160.0	95.0	130.0	138.0	75.0	118.0	21.5
731	27.0	14.5	185.0	100.0	140.0	140.5	80.0	115.0	28.5
741	26.0	11.0	180.0	105.0	150.0	150.0	80.0	125.0	25.0
744	19.0	12.5	170.0	95.0	135.0	147.0	65.0	117.0	27.0
746	21.5	12.0	180.0	105.0	140.0	155.0	80.0	130.0	25.0
748	26.0	7.5	160.0	100.0	150.0	145.0	75.0	130.0	27.5
753	15.0	13.0	160.0	90.0	125.0	140.0	75.0	120.0	27.0

759	24.5	10.0	170.0	100.0	140.0	148.0	85.0	125.0	28.5
762	25.5	9.0	185.0	105.0	145.0	150.0	88.0	120.0	27.0
765	20.0	11.0	175.0	95.0	140.0	135.0	75.0	115.0	29.0
767	20.0	12.0	175.0	100.0	130.0	145.0	85.0	120.0	30.0
769	17.0	14.0	190.0	100.0	155.0	140.0	85.0	125.0	31.0
774	15.0	7.0	170.0	90.0	130.0	145.0	80.0	115.0	26.0
747	20.0	10.0	175.0	95.0	145.0	155.0	90.0	130.0	25.5
775	24.0	9.0	175.0	100.0	147.0	140.0	87.0	.	29.5
778	22.0	12.0	185.0	105.0	140.0	150.0	80.0	125.0	26.5
779	19.0	10.0	155.0	90.0	130.0	148.0	75.0	120.0	23.0
781	18.0	14.0	178.0	100.0	145.0	140.0	80.0	115.0	27.0
801	18.5	11.0	175.0	100.0	140.0	155.0	100.0	130.0	24.0
805	21.0	12.0	170.0	105.0	140.0	145.0	78.0	123.0	27.0
809	21.0	8.0	180.0	100.0	140.0	145.0	70.0	120.0	25.0
810	20.0	10.0	175.0	110.0	147.0	150.0	90.0	120.0	30.0

ID	L_OCCI	B_OCCI	M1	M5	M7	M8	M9	M10	M16
811	23.0	11.0	180.0	100.0	140.0	142.0	90.0	110.0	28.0
814	19.0	8.0	170.0	90.0	135.0	135.0	70.0	115.0	25.0
824	22.0	7.5	160.0	90.0	127.0	142.0	75.0	120.0	27.5
835	27.0	10.0	185.0	110.0	145.0	145.0	85.0	120.0	25.0
842	25.0	11.0	170.0	105.0	145.0	135.0	80.0	110.0	25.0
843	24.0	9.0	170.0	100.0	140.0	148.0	80.0	115.0	27.0
849	21.0	10.0	180.0	105.0	145.0	140.0	80.0	115.0	26.5
854	24.0	9.0	170.0	100.0	140.0	155.0	85.0	130.0	25.0
867	22.0	10.0	170.0	100.0	135.0	140.0	70.0	105.0	27.0
870	19.0	10.0	185.0	100.0	135.0	140.0	85.0	120.0	26.0
857	20.0	9.0	175.0	100.0	140.0	145.0	80.0	110.5	27.0
875	19.0	14.0	160.0	95.0	140.0	140.0	72.0	112.0	26.0
883	24.0	10.0	170.0	105.0	145.0	145.0	85.0	125.0	30.5
887	18.0	8.5	165.0	90.0	140.0	140.0	80.0	120.0	24.5
893	16.0	7.0	170.0	100.0	140.0	150.0	82.0	125.0	26.0
895	25.0	11.0	175.0	100.0	145.0	145.0	75.0	120.0	26.0
898	24.5	10.0	175.0	100.0	145.0	140.0	85.0	115.0	24.0
899	17.5	10.5	170.0	105.0	140.0	137.0	75.0	113.0	27.0
902	21.0	14.0	180.0	100.0	150.0	140.0	80.0	120.0	29.0
904	22.0	7.0	170.0	95.0	140.0	140.0	75.0	100.0	26.0
906	17.0	9.0	160.0	90.0	135.0	140.0	80.0	120.0	25.0
908	19.0	9.0	180.0	95.0	140.0	140.0	90.0	120.0	27.5
909	20.0	9.0	170.0	107.0	145.0	.	80.0	127.0	27.0
911	23.0	11.5	170.0	100.0	140.0	140.0	80.0	120.0	23.0
913	21.5	10.5	175.0	100.0	140.0	150.0	75.0	120.0	25.0
914	19.0	12.5	180.0	110.0	150.0	145.0	85.0	125.0	26.0
922	22.0	11.0	177.0	110.0	150.0	150.0	82.0	132.0	29.0
923	24.0	13.5	185.0	110.0	150.0	150.0	80.0	130.0	27.0

925	19.0	8.0	168.0	95.0	140.0	148.0	80.0	125.0	25.5
927	24.0	10.0	180.0	100.0	140.0	150.0	80.0	125.0	28.0
928	24.0	10.0	170.0	100.0	140.0	145.0	80.0	122.0	29.0
929	19.0	13.0	180.0	105.0	150.0	158.0	95.0	132.0	28.0
930	22.0	13.0	185.0	110.0	140.0	145.0	75.0	110.0	28.5
931	15.0	10.0	180.0	100.0	133.0	155.0	90.0	130.0	28.0
932	20.0	13.5	175.0	100.0	135.0	145.0	90.0	120.0	29.0
933	23.0	9.0	165.0	100.0	135.0	145.0	75.0	120.0	24.0
934	20.0	10.5	180.0	95.0	145.0	145.0	80.0	125.0	29.5
936	12.0	7.0	160.0	90.0	120.0	150.0	68.0	125.0	24.0
938	28.0	10.0	170.0	105.0	140.0	150.0	80.0	125.0	25.5
939	13.5	10.0	175.0	100.0	140.0	140.0	80.0	120.0	24.5
940	19.0	10.0	170.0	100.0	140.0	148.0	80.0	128.0	25.5
941	22.5	10.0	160.0	90.0	130.0	147.0	85.0	120.0	26.5
942	21.0	12.5	175.0	100.0	132.0	142.0	77.0	120.0	27.0
943	20.0	12.0	180.0	100.0	150.0	150.0	85.0	100.0	31.5
944	23.0	10.5	170.0	105.0	150.0	148.0	80.0	127.0	23.5
945	21.0	11.0	170.0	100.0	145.0	140.0	85.0	120.0	25.0
947	19.0	8.5	165.0	90.0	135.0	147.0	80.0	125.0	26.0
949	21.0	12.0	165.0	90.0	135.0	145.0	75.0	115.0	26.5
950	23.5	9.0	185.0	95.0	140.0	140.0	75.0	120.0	27.0
953	23.0	10.0	185.0	105.0	140.0	150.0	88.0	125.0	26.0
966	20.0	17.5	170.0	90.0	135.0	140.0	75.0	120.0	26.0

ID	M17	M23	M24	M25	M26	M29	M40	M42	M44
504	33.0	280.0	320.0	390.0	140.0	112.5	94.5	113.0	92.5
517	35.0	300.0	325.0	390.0	135.0	113.0	95.0	100.0	98.0
540	33.0	290.0	320.0	370.0	130.0	108.0	91.0	115.0	101.0
544	35.0	265.0	320.0	365.0	130.0	110.0	102.0	105.0	100.0
522	36.0	270.0	323.0	355.0	120.0	107.0	100.0	120.0	100.0
552	32.0	290.0	315.0	380.0	130.0	110.0	95.0	105.0	94.0
556	35.0	270.0	330.0	365.0	137.0	117.0	101.0	116.0	95.0
569	27.0	255.0	305.0	360.0	120.0	100.0	85.0	100.0	95.0
576	30.0	235.0	295.0	350.0	130.0	110.0	90.0	110.0	89.0
581	38.0	240.0	315.0	355.0	130.0	105.0	90.0	130.0	102.0
595	39.0	280.0	315.0	370.0	130.0	111.0	95.0	100.0	100.0
602	31.0	260.0	310.0	365.0	130.0	109.0	95.5	101.5	91.0
603	30.0	255.0	315.0	355.0	132.0	109.0	93.0	98.0	88.0
607	32.0	250.0	320.0	365.0	125.0	103.0	85.0	110.0	97.5
613	28.5	260.0	295.0	355.0	130.0	106.0	95.0	103.0	91.0
629	29.0	280.0	320.0	360.0	130.0	109.0	86.5	104.5	89.0
632	35.0	220.0	305.0	365.0	130.0	105.0	90.0	130.0	93.0
638	29.0	290.0	345.0	410.0	150.0	124.0	100.0	101.0	96.0
641	30.0	250.0	320.0	362.0	135.0	108.0	85.0	110.0	90.5
656	29.0	240.0	310.0	350.0	127.0	108.5	90.0	115.0	94.5
658	30.0	245.0	310.0	360.0	125.0	105.0	90.0	110.0	90.0
660	32.5	250.0	320.0	355.0	125.0	106.0	105.0	125.0	98.0

682	32.0	260.0	320.0	363.0	135.0	112.0	95.0	111.0	100.0
684	33.5	265.0	315.0	375.0	138.0	112.0	87.0	117.0	95.0
693	30.0	265.0	335.0	380.0	135.0	114.0	85.0	105.0	98.5
715	31.0	270.0	318.0	380.0	130.0	109.0	91.0	117.0	98.0
717	31.0	270.0	325.0	380.0	135.0	114.5	95.5	114.5	98.0
719	26.5	240.0	290.0	340.0	120.0	98.5	86.0	100.0	90.0
731	29.0	275.0	315.0	375.0	140.0	114.5	100.0	110.0	95.5
741	28.0	270.0	330.0	390.0	140.0	115.0	105.0	108.0	99.0
744	35.0	250.0	305.0	358.0	130.0	107.0	90.0	96.0	87.0
746	30.5	270.0	330.0	375.0	130.0	109.0	90.0	123.0	97.0
748	35.5	265.0	330.0	360.0	138.0	112.0	95.0	113.5	88.0
753	30.0	275.0	310.0	345.0	120.0	99.0	100.0	105.0	91.0
759	33.0	235.0	320.0	360.0	128.0	108.5	92.5	102.0	100.0
762	35.0	265.0	335.0	392.0	150.0	121.0	98.0	119.0	100.0
765	34.5	290.0	305.0	370.0	130.0	109.0	85.0	115.0	91.5
767	36.0	280.0	315.0	350.0	130.0	105.5	92.0	116.0	101.0
769	31.0	280.0	345.0	410.0	150.0	125.0	100.0	119.0	99.5
774	34.0	250.0	310.0	360.0	124.0	105.0	90.0	96.5	90.0
747	29.0	265.0	335.0	390.0	140.0	117.0	80.0	100.0	102.0
775	32.5	250.0	.	380.0	130.0	112.0	90.0	91.5	95.5
778	34.5	280.0	325.0	380.0	135.0	112.5	90.5	100.5	102.0
779	27.0	240.0	295.0	330.0	120.0	100.0	81.0	96.0	85.0
781	39.0	270.0	300.0	365.0	135.0	111.0	92.0	123.0	94.0
801	23.0	255.0	345.0	380.0	140.0	113.0	95.0	110.0	97.0
805	32.0	260.0	310.0	350.0	130.0	109.0	90.0	105.0	95.0
809	29.0	260.0	310.0	370.0	135.0	113.5	95.0	107.5	95.0
810	35.0	260.0	340.0	370.0	130.0	115.0	110.0	107.0	104.0

ID	M17	M23	M24	M25	M26	M29	M40	M42	M44
811	32.0	270.0	320.0	380.0	135.0	110.0	100.0	114.0	96.0
814	31.0	255.0	300.0		130.0	109.0	85.5	101.0	87.0
824	29.0	245.0	300.0	350.0	120.0	97.5	85.0	98.0	92.0
835	36.0	260.0	305.0	380.0	140.0	118.0	100.0	115.5	99.0
842	30.0	255.0	315.0	365.0	125.0	105.0	97.0	102.5	91.5
843	33.0	250.0	310.0	360.0	120.0	102.0	86.5	95.5	92.0
849	33.5	290.0	320.0	365.0	130.0	108.0	100.0	117.0	92.0
854	33.0	265.0	335.0	360.0	125.0	106.0	101.0	108.0	99.0
867	31.0	250.0	295.0	355.0	125.0	104.5	90.5	100.0	91.5
870	32.5	275.0	310.0	380.0	135.0	112.0	94.5	110.0	96.0
857	34.0	275.0	320.0	375.0	130.0	111.0	90.0	100.0	90.0
875	31.0	265.0	310.0	358.0	125.0	101.0	100.0	115.0	93.0
883	35.5	260.0	320.0	360.0	130.0	109.0	90.0	99.5	94.5
887	29.0	270.0	315.0	370.0	130.0	108.0	96.0	110.0	92.5
893	31.0	260.0	320.0	360.0	130.0	108.0	85.0	105.0	98.0

895	36.0	250.0	305.0	362.0	130.0	107.5	95.0	100.0	97.5
898	31.0	250.0	315.0	365.0	127.0	107.0	85.0	110.0	91.5
899	31.5	260.0	300.0	352.0	123.0	102.5	105.0	110.0	98.0
902	.	270.0	310.0	.	137.0	114.0	100.0	105.0	91.0
904	31.0	270.0	305.0	368.0	130.0	108.0	90.0	100.0	89.0
906	27.0	270.0	305.0	360.0	128.0	105.5	86.5	93.5	96.0
908	31.0	260.0	320.0	392.0	138.0	112.0	82.0	104.5	90.5
909	33.0	250.0	320.0	365.0	130.0	108.0	95.0	125.0	98.0
911	29.5	260.0	310.0	365.0	125.0	108.5	95.5	113.0	96.0
913	30.0	240.0	320.0	360.0	125.0	108.5	100.0	111.0	95.0
914	32.5	295.0	335.0	380.0	140.0	121.5	100.0	110.0	102.0
922	37.0	260.0	335.0	380.0	142.0	117.0	105.0	116.5	103.0
923	36.0	260.0	330.0	392.0	137.0	116.5	105.0	119.0	104.5
925	31.0	250.0	330.0	362.0	130.0	107.5	95.0	99.0	94.0
927	35.0	260.0	315.0	375.0	135.0	110.0	100.0	108.0	98.5
928	30.0	250.0	320.0	360.0	130.0	106.5	100.0	110.0	93.5
929	31.0	270.0	355.0	388.0	135.0	113.0	99.0	121.0	105.0
930	33.0	260.0	300.0	370.0	130.0	109.0	100.0	105.0	91.0
931	30.0	270.0	325.0	372.0	140.0	115.0	100.0	110.0	96.5
932	30.0	265.0	315.0	370.0	135.0	111.0	100.0	110.0	100.0
933	26.5	240.0	320.0	358.0	130.0	108.0	95.0	110.0	96.0
934	35.5	265.0	320.0	385.0	135.0	113.0	90.0	100.0	98.0
936	39.0	245.0	320.0	325.0	120.0	98.5	95.0	105.0	88.0
938	35.0	260.0	330.0	360.0	130.0	108.0	100.0	114.0	91.0
939	26.0	255.0	315.0	370.0	130.0	108.0	95.0	100.0	97.0
940	32.5	260.0	318.0	370.0	125.0	107.0	95.0	107.5	97.0
941	33.5	245.0	300.0	345.0	110.0	94.0	90.0	114.0	97.0
942	32.0	250.0	300.0	355.0	125.0	106.5	100.0	107.0	94.0
943	34.0	260.0	330.0	390.0	140.0	117.5	90.0	102.0	93.0
944	34.0	260.0	330.0	377.0	130.0	109.0	100.0	110.0	97.0
945	28.5	265.0	315.0	365.0	132.0	108.0	90.0	100.0	88.5
947	28.5	270.0	315.0	360.0	120.0	103.5	85.0	86.5	91.0
949	31.5	248.0	310.0	350.0	124.0	106.0	93.5	94.0	88.0
950	33.0	277.0	315.0	390.0	130.0	116.0	78.0	99.5	94.0
953	32.0	255.0	325.0	370.0	135.0	114.0	93.5	109.0	97.0
966	30.0	244.0	300.0	360.0	130.0	108.0	84.0	101.0	92.5

ID	M45	M47	M48	M49	M50	M51	M52	M57	M57I
504	130.0	87.5	65.5	15.0	10.0	40.0	32.5	4.0	12.5
517	135.0	128.0	75.0	20.5	16.0	40.0	36.0	3.5	7.5
540	140.0	86.0	65.0	22.0	16.0	42.0	34.0	4.0	13.0
544	140.0	117.0	72.5	24.0	17.0	39.0	33.0	9.0	16.0
522	135.0	96.0	68.0	22.5	20.0	41.5	33.5	7.5	16.0
552	130.0	116.0	69.0	19.5	13.0	40.0	32.0	4.0	14.0
556	140.0	103.0	62.0	20.0	15.0	41.0	31.0	4.5	14.0
569	130.0	100.0	60.5	20.5	16.0	40.0	31.5	4.0	13.0
576	130.0	97.0	68.5	18.5	13.0	38.5	33.0	4.0	12.0

581	150.0	86.0	64.0	19.0	12.0	42.0	37.0	2.0	8.0
595	140.0	108.5	64.0	21.0	14.0	43.0	38.0	7.0	13.5
602	125.0	109.0	63.0	19.0	12.0	37.0	32.0	4.0	14.0
603	125.0	106.0	62.5	18.0	12.0	39.0	31.0	1.0	16.0
607	130.0	96.0	60.0	21.0	15.0	41.0	31.5	5.0	15.0
613	120.0	107.0	65.0	21.0	19.0	36.0	32.0	6.0	16.0
629	125.0	80.0	57.5	16.5	10.0	38.0	31.5	3.5	14.0
632	125.0	81.0	58.0	20.0	15.0	40.0	37.0	5.0	12.5
638	130.0	108.0	62.5	23.0	20.0	37.0	33.0	9.0	14.5
641	130.0	69.0	52.5	18.0	13.0	35.5	32.0	1.5	11.5
656	130.0	70.0	55.0	21.0	14.0	41.0	32.0	8.0	14.0
658	125.0	66.0	48.0	19.0	14.0	36.0	34.0	5.0	18.0
660	145.0	81.0	61.0	24.0	18.0	37.0	32.0	10.0	16.0
682	145.0	107.0	68.0	20.5	15.5	44.0	33.0	4.0	14.5
684	140.0	109.0	68.0	21.0	16.0	39.0	32.0	3.5	14.0
693	140.0	99.5	62.5	23.0	12.0	41.0	33.0	8.0	16.0
715	150.0	85.0	61.0	22.5	18.5	39.0	32.0	7.0	15.0
717	130.0	99.0	71.0	22.0	16.0	41.5	33.5	6.0	12.0
719	128.0	103.5	61.0	19.0	14.5	36.0	32.5	3.0	12.0
731	140.0	111.0	65.0	21.0	15.0	41.0	32.0	6.5	15.0
741	135.0	118.0	70.0	23.0	17.0	41.0	31.0	6.0	15.0
744	120.0	106.0	64.5	16.0	13.0	39.0	36.0	5.0	11.5
746	140.0	73.0	60.0	20.5	14.0	40.5	32.5	7.0	15.0
748	130.0	116.0	65.0	18.0	13.0	36.0	32.0	3.0	11.0
753	125.0	115.0	68.0	21.0	12.0	41.0	35.0	4.0	16.0
759	140.0	122.5	72.5	24.0	18.0	41.0	32.0	6.5	14.5
762	140.0	121.0	71.0	22.0	15.0	42.0	31.0	7.0	15.0
765	130.0	81.0	59.0	17.0	12.0	32.0	31.0	4.5	12.0
767	135.0	84.0	63.0	25.0	19.0	41.0	35.0	4.0	14.0
769	140.0	130.0	71.5	22.5	14.0	40.0	33.0	6.0	14.0
774	125.0	108.0	66.0	19.0	15.0	37.0	34.5	7.5	13.5
747	140.0	123.5	69.0	23.0	14.0	41.5	34.5	5.5	13.5
775	140.0	125.0	72.5	24.0	16.5	37.5	35.0	4.0	15.0
778	140.0	122.5	73.0	24.0	16.0	44.0	35.0	9.0	14.5
779	130.0	105.0	61.0	17.5	11.0	35.5	29.0	4.0	10.0
781	135.0	98.0	71.0	22.0	16.0	38.0	32.0	1.5	13.0
801	140.0	94.0	62.0	23.0	18.5	39.0	32.0	7.0	16.0
805	130.0	128.0	71.5	23.0	17.5	40.0	36.5	5.5	13.5
809	130.0	122.0	71.0	22.5	17.5	37.0	35.0	9.0	15.0
810	150.0	119.0	68.5	25.0	19.0	43.0	38.0	9.5	18.0
843	130.0	94.5	60.5	19.0	16.0	40.5	30.0	4.0	9.0

ID	M45	M47	M48	M49	M50	M51	M52	M57	M57I
811	135.0	112.0	64.0	22.0	17.0	39.5	30.0	2.0	14.0
814	115.0	84.0	64.0	17.0	13.0	36.0	33.0	5.0	12.0
824	122.0	98.5	54.5	18.0	12.0	38.0	33.0	4.0	13.0

835	140.0	82.5	63.0	22.0	15.0	39.0	32.0	8.0	17.0
842	135.0	112.0	62.5	19.5	13.0	40.0	30.0	5.0	14.0
849	130.0	111.0	63.5	20.0	13.0	38.0	32.0	5.0	15.0
854	140.0	111.0	68.0	22.0	16.0	40.0	32.5	7.0	14.0
867	130.0	91.0	61.0	19.0	11.5	38.5	30.5	4.5	13.5
870	135.0	107.0	70.0	18.0	13.5	42.0	32.0	5.0	14.0
857	130.5	97.0	67.0	17.5	13.0	37.5	30.5	3.0	14.0
875	135.0	101.0	59.0	20.0	15.0	38.0	32.0	7.5	17.5
883	135.0	127.5	73.0	19.0	14.0	40.0	38.5	5.0	14.0
887	125.0	108.5	68.5	18.0	13.0	38.0	30.5	5.0	13.0
893	140.0	75.0	55.0	21.0	15.0	40.0	37.0	7.0	14.0
895	130.0	108.0	68.0	22.0	17.5	40.0	34.5	5.5	13.5
898	132.0	90.0	67.0	16.5	11.5	38.0	36.0	4.0	12.5
899	135.0	115.0	65.0	17.5	11.0	41.5	30.0	1.5	11.0
902	125.0	100.0	57.0	16.0	12.0	39.5	33.0	0.5	.
904	130.0	100.0	65.0	18.0	14.0	36.0	34.0	4.5	13.5
906	125.0	110.0	65.0	22.0	15.5	38.0	32.5	7.5	12.5
908	130.0	96.0	56.0	19.0	14.5	36.0	30.0	6.0	15.0
909	135.0	72.0	62.0	23.5	15.0	41.5	33.5	5.0	12.0
911	140.0	110.0	67.0	19.0	14.0	41.0	31.5	5.0	14.0
913	127.0	115.5	66.0	18.0	15.0	40.5	38.0	6.0	16.0
914	140.0	115.5	66.0	22.0	17.0	43.0	35.0	7.5	15.0
922	145.0	116.0	74.5	21.5	15.0	42.5	35.0	5.0	15.5
923	145.0	136.0	78.0	22.0	17.0	44.0	41.0	6.0	17.0
925	130.0	105.5	62.0	19.0	14.0	39.5	31.5	5.0	13.5
927	135.0	119.0	69.0	21.0	16.0	41.0	37.0	7.0	14.0
928	135.0	98.5	64.0	20.0	14.0	41.0	33.5	3.0	13.3
929	145.0	128.5	73.0	25.0	18.0	42.0	34.0	10.0	17.0
930	130.0	123.0	66.0	17.0	13.0	41.0	31.5	3.0	15.0
931	130.0	77.5	60.0	24.0	17.0	38.0	32.0	7.0	15.0
932	140.0	126.0	77.0	26.0	18.5	41.0	34.0	7.0	15.0
933	125.0	81.5	62.5	18.0	15.0	37.0	35.0	8.0	18.0
934	135.0	102.0	63.0	20.0	15.5	39.5	31.5	5.0	15.0
936	120.0	100.0	55.5	20.5	17.0	35.0	34.0	6.0	14.0
938	135.0	120.0	69.5	19.0	14.5	40.0	36.0	2.0	12.5
939	130.0	119.5	69.0	23.5	16.5	39.5	32.0	8.5	11.0
940	135.0	122.5	68.0	21.5	15.0	39.0	33.0	4.0	12.0
941	130.0	120.0	67.0	22.0	16.0	39.0	34.0	3.0	15.5
942	132.0	122.0	73.0	22.0	11.5	40.0	30.0	4.0	12.5
943	135.0	134.5	71.0	21.0	13.5	39.5	32.0	4.0	16.0
944	135.0	121.0	70.0	22.0	15.0	39.0	34.5	3.0	13.0
945	130.0	114.0	64.0	20.5	15.0	38.0	31.0	5.0	14.5
947	125.0	107.0	63.0	19.0	13.0	38.0	33.0	2.0	11.0
949	125.0	114.0	71.5	17.5	11.0	37.0	33.0	3.0	15.0
950	130.0	94.0	67.5	21.0	15.0	40.0	33.0	4.0	12.0
953	140.0	120.0	71.5	21.0	11.5	42.0	31.0	4.0	14.0
966	125.0	95.5	57.5	20.0	15.0	35.0	39.5	3.0	14.5

ID	M65	M66	M70	M71	M79
504	114.0	96.5	50.0	32.0	127.0
517	112.0	94.0	60.0	29.0	125.0
540	128.0	105.0	69.0	33.0	113.0
544	122.5	100.0	66.0	32.0	113.0
522	117.0	107.5	63.0	34.5	120.0
552	115.0	94.0	51.5	28.0	133.0
556	126.0	94.5	52.5	31.0	120.0
569	114.0	91.0	63.5	30.5	107.0
576	113.0	98.0	59.0	33.0	120.0
581	118.0	103.5	69.0	31.0	125.0
595	121.0	95.0	68.0	30.0	110.0
602	116.0	87.0	60.0	27.0	120.0
603	109.0	86.5	61.0	29.0	115.0
607	121.0	97.5	55.0	28.0	118.0
613	106.0	87.0	51.0	24.0	131.0
629	116.5	90.0	51.0	30.5	119.0
632	127.0	100.0	69.0	36.0	105.0
638	110.0	90.0	56.0	29.5	125.0
641	115.5	90.0	57.0	28.0	118.0
656	117.5	90.5	63.5	34.5	110.0
658	116.0	84.0	61.5	32.0	111.0
660	121.0	95.0	51.0	32.0	124.0
682	117.0	95.0	60.5	31.0	121.0
684	126.0	102.0	66.0	28.0	115.0
693	131.0	97.0	65.0	27.0	119.0
715	123.0	99.0	75.0	31.0	107.0
717	121.5	88.0	61.0	28.0	122.0
719	110.0	90.0	55.0	26.0	120.0
731	126.0	101.0	61.0	33.5	120.0
741	121.0	107.0	66.0	33.5	117.0
744	109.5	93.0	48.5	25.5	132.0
746	118.0	111.5	65.0	34.0	116.0
748	118.0	86.0	71.0	36.0	105.0
753	113.0	93.0	63.0	29.0	130.0
759	123.5	92.0	71.0	30.0	108.0
762	124.0	102.0	68.0	37.0	113.0
765	117.5	91.0	53.0	30.0	126.5
767	120.0	107.0	62.0	30.0	129.0
769	116.5	94.0	77.0	35.0	121.0
774	106.5	95.0	58.0	28.0	122.0
747	120.0	105.0	66.0	30.0	116.0
775	123.0	101.0	57.0	31.0	125.0
778	124.0	98.0	47.0	25.5	139.0

779	118.0	94.0	49.0	22.0	131.0
781	126.5	100.0	77.0	26.0	118.0
801	130.5	93.5	58.5	32.0	120.0
805	116.0	89.5	59.0	31.5	116.0
809	108.0	94.5	72.0	28.0	122.0
810	135.0	104.0	62.0	31.0	120.0

ID	M65	M66	M70	M71	M79
811	121.5	99.0	62.0	27.0	125.0
814	106.5	83.5	55.0	22.0	130.0
824	107.0	86.5	55.5	25.5	119.0
835	131.0	108.0	71.0	33.0	115.0
842	117.0	93.0	58.0	28.5	119.0
843	119.0	89.0	58.5	29.0	112.0
849	115.0	98.0	61.0	27.0	131.0
854	123.0	93.5	61.0	34.0	113.0
867	120.5	92.5	58.0	31.0	114.0
870	120.0	98.5	54.0	30.0	117.0
857	115.5	93.0	53.0	28.0	128.0
875	118.0	100.0	65.0	32.0	110.0
883	107.0	96.0	67.0	25.0	126.5
887	110.0	89.0	59.0	27.5	132.0
893	120.0	93.5	60.0	26.0	113.0
895	120.0	98.5	62.5	33.0	113.0
898	115.0	87.0	64.0	29.0	122.5
899	126.0	89.0	64.5	35.0	110.0
902	120.0	98.5	63.0	26.5	116.0
904	111.0	91.0	56.0	27.0	129.0
906	117.0	91.5	55.0	24.5	138.0
908	120.5	92.0	54.5	29.0	113.5
909	118.5	97.5	60.0	27.0	127.0
911	122.0	103.0	68.0	33.0	114.0
913	107.0	83.0	63.0	32.0	127.0
914	122.0	98.0	67.0	33.0	121.0
922	134.0	99.0	66.0	34.0	126.0
923	123.5	108.0	72.0	34.0	117.5
925	109.5	91.0	50.0	25.0	124.0
927	121.0	98.0	64.0	29.0	121.0
928	120.0	94.5	61.0	38.0	117.0
929	122.0	98.0	76.0	25.0	120.0
930	120.0	97.0	63.5	30.0	123.0
931	117.0	93.0	52.0	34.0	119.0
932	120.5	101.0	67.5	30.0	114.0
933	112.0	83.0	63.0	32.0	121.5
934	117.0	106.0	51.5	30.5	123.0
936	104.5	86.0	43.0	23.0	129.0

938	112.0	87.0	78.5	32.0	110.0
939	111.0	94.0	57.0	28.5	122.5
940	117.0	95.5	65.0	28.0	109.0
941	116.0	93.0	57.0	22.5	129.0
942	123.0	89.0	53.0	28.0	124.0
943	121.0	101.0	58.0	25.5	135.0
944	124.0	106.0	71.0	31.0	119.0
945	114.5	93.5	64.0	27.5	122.0
947	113.0	93.0	50.0	20.0	129.0
949	105.0	82.5	56.0	24.5	119.0
950	115.0	90.5	58.0	24.5	126.0
953	125.5	97.0	62.0	29.5	122.0
966	110.0	89.0	55.0	26.0	129.0

APPENDIX C

Data for 32 unknown skulls to test validity of multiple logistic regression equation derived from 101 skulls.

id	sex	age	m5	m8	m40	m45	z	Prob(M)
1	1	40	110	150	88	140	4.9560	0.9930
2	1	35	105	140	96	135	4.9930	0.9933
10	1	60	100	145	86	140	2.8730	0.9465
11	1	54	100	145	85	135	1.1640	0.7621
12	1	35	100	140	95	135	3.4690	0.9698
15	1	43	100	145	91	140	3.5430	0.9719
16	1	28	95	140	89	120	-3.4500	0.0308
17	1	51	100	140	98	140	5.4460	0.9957
18	1	25	100	150	97	140	3.3820	0.9671
19	1	50	105	150	96	140	4.6380	0.9904
20	1	55	100	140	89	130	1.0900	0.7484
21	1	60	100	160	88	145	1.8210	0.8607
23	1	22	100	150	112	145	6.9670	0.9991
25	1	20	105	145	95	140	5.4690	0.9958
26	1	43	95	145	83	125	-3.6440	0.0255
27	1	67	100	145	86	140	2.8730	0.9465
28	1	25	100	140	100	130	2.5640	0.9285
29	1	67	110	150	100	140	6.5640	0.9986
30	1	38	110	145	100	140	7.5290	0.9995
32	1	55	100	150	86	145	3.4830	0.9702
3	2	40	100	140	88	135	2.5310	0.9263
4	2	22	100	155	95	145	3.7240	0.9764
5	2	50	95	145	84	130	-1.9350	0.1262
6	2	23	100	145	86	135	1.2980	0.7855
7	2	40	100	140	94	130	1.7600	0.8532
8	2	20	100	140	85	125	-1.0210	0.2648
9	2	.	100	135	89	125	0.4800	0.6177
13	2	30	90	135	87	120	-4.1430	0.0156
14	2	22	100	140	89	120	-2.0600	0.1130
22	2	.	95	140	91	135	1.5430	0.8239
24	2	40	100	135	89	130	2.0550	0.8865
31	2	28	90	150	90	125	-5.0610	0.0063

Note : Sex 1 = Male, 2 = Female, Prob (M) = Predicted probability of being male using multiple logistic regression equation, Prob (M) > 0.5 predicted to be Male, Prob (M) < 0.5 predicted to be Female, Blue shade = wrong predicted by this method.

$$Z = -52.566 + 0.278\ M5 - 0.193\ M8 + 0.134\ M40 + 0.315\ M45$$

BIOGRAPHY

NAME	Mr. Komon Boonkaew
DATE OF BIRTH	18 October 1976
PLACE OF BIRTH	Uttaradit, Thailand
INSTITUTIONS ATTENDED	Chulalongkorn University, 2000:
	Bachelor of Education
	(Health Education)
	Mahidol University, 2005
	Master of Science (Anatomy)
HOME ADDRESS	8 Moo 2, Sing, Bangrajan,
	Singhaburi, Thailand 16130
	Tel. 0-3653-4598
	E-mail: g4436560@yahoo.com