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Stature in Yogyakarta's students and prehistoric Balinese circa 1100 A.C.

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ABSTRACT

Etty Indriati - ***Stature in Yogyakarta's student's and prehistoric Balinese circa 1100 A.C.***

Background: Stature is one of growth and development indicators among others such as weight, dental eruption, and bone development. Stature varies between populations and races, and changes across times and spaces.
Aim of study: to understand the average stature of groups of Indonesians relative to other populations worldwide; and to understand the anthropological category of Indonesians stature.
Material and methods: Subjects were students of National University of Yogyakarta consisted of 245 people. Sex, age and their statures were recorded. In addition, the stature of 47 human skeletal remains from prehistoric Bali were measured utilizing regression formula of Mongolid race.
Results: The average stature of Yogyakarta National University students in 1980s was 165 cm and 152.8 cm in males and females respectively. In the 1990s, their statures were 165.4 cm and 153.7 cm respectively. The prehistoric Balinese circa 1100 A.D. had statures of 164.4 cm and 157.3 cm in males and females respectively.
Conclusion: Increased stature of 0.4 cm in males and 0.9 cm in females among Yogyakarta students in one decade might have been related to better nutrition, social and economy from the 80s to the 90s. Within two millennia, Indonesian' stature has not undertook significance change. Indonesian stature is medium relative to other population's stature worldwide; and in the range of stature of people from China, Hongkong, Taiwan, Thailand, and India. However, Indonesian stature is below the average stature of European and American people. This suggests that race/genetics are more prominent as contributing factors reaching terminal stature, compared to latitude (weather and geograpy).

Key words: stature, Yogyakarta, Bali, anthropology, 'growth

ABSTRAK

Etty Indriaty - ***Tinggi badan sebagian mahasiswa di Yogyakarta dan prehistoris Bali 1100 tahun sesudah masehi***

Latar belakang: Tinggi badan merupakan salah satu indikator pertumbuhan selain berat badan, erupsi gigi, dan pertumbuhan tulang. Tinggi badan bervariasi antar populasi, antar ras dan berubah dari masa ke masa meskipun pada populasi dan ras yang sama.
Tujuan penelitian: Untuk mengetahui tinggi badan rata-rata kelompok orang Indonesia, dan nilai tinggi badan mereka relatif terhadap tinggi badan berbagai populasi lain di dunia.
Bahan dan cara: Bahan penelitian ini adalah mahasiswa dan mahasiswi Universitas Nasional Yogyakarta sebanyak 245 orang. Jenis kelamin, umur, dan tinggi badan didata. Sebanyak 47 rangka prehistoris Bali circa 1100 A.D. ditentukan tinggi badannya berdasarkan rumus regresi ras Mongolid.
Hasil: Tinggi badan mahasiswa Universitas Nasional Yogyakarta laki-laki dan perempuan dekade 1980an berturut-turut adalah 165 cm dan 152,8 cm, dan dekade 1990an berturut-turut adalah 165,4 cm dan 153,7 cm. Tinggi badan rata-rata rangka prehistoris Bali 1100 tahun sesudah masehi adalah 164,4 cm and 157,3 cm pada laki-laki dan perempuan.

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Simpulan: Peningkatan tinggi badan sebanyak 0,4 cm pada laki-laki dan 0,9 cm pada perempuan selama satu dekade menunjukkan kemungkinan peningkatan nutrisi dan sosial ekonomi pada mahasiswa UNY. Dalam dua abad, tinggi badan orang Indonesia relatif tidak mengalami perubahan yang berarti. Tinggi orang Indonesia tergolong sedang (*mesosome*) dibanding kelompok masyarakat lain di dunia; dan dalam kisaran tinggi badan rata-rata orang Cina, Hongkong, Taiwan, Thailand, dan India. Namun demikian, tinggi badan orang Indonesia di bawah tinggi badan rata-rata orang Eropa dan Amerika. Hal ini menunjukkan bahwa ras/genetik lebih merupakan faktor yang berperan untuk mencapai tinggi badan akhir, dibanding latitud (iklim dan geografi).

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INTRODUCTION

Biological anthropology studies cultural and biological variation, causes, mechanism and consequences of the variation, in time and space. Based on this definition, the scope of biological anthropology is very broad. For instance, in the context of time and space, it includes modern time (thus the subject of study is living humans or extant humans). In the context of past time, the subject of study is skeletal remains, either from prehistoric sites or fossilized or extinct remains from ancient times. Morphology and measurement, known as anthroposcopy and anthropometry, is a common tool used in the discipline of biological anthropology of the livings[1]; while in skeletal remains, it is discussed in bioarchaeology[2].

In his book "Practical Anthropology" that has been widely referred among anthropologists, Olivier[3] lists anthropometry both for the livings and the skeleton. Anthropometry for the living includes the measurement of stature, torso length, torso transversal dimension, torso's circumference, measurement of hands and feet, weight and robusticity, as well as head and face. In addition, the characteristic of pigment, hair (pilosity), fingerprints (dermatoglyphi), sensitivity toward Phenylthiocarbamide PTC on tongue, color of eyes, and mongolian spot also studied in the living anthropology. In case of living measurement, Henry[4] states that body size could be analyzed in 3 observations: stature (one dimension); measurement of body's surface (two dimensions); and weightor ponderal growth (3 dimensions).

In this study, stature is approached from biological anthropology in time difference. The modern people studied is living population of National University Students in Yogyakarta, year of 1980-1999 and the prehistoric population is the skeletons of Balinese archaeological remains circa 1100 A.C. The skeletal stature was calculated based on the regression formula of Trotter and Glesser[5] while living stature was measured using anthropometer. The stature of these two human groups from different time period will give us insight whether Indonesian's stature increased, decreased, or about the same in one millenia, from 1000 A.C. to around 1980-1990.

STATURE: GROWTH INDICATOR THAT IS SEXUALLY DIMORPHIC

Stature is one growth parameter that often studied by scholar of growth and development, medical science, anthropology, and biology. Human's stature keeps increasing from the time of conception to the period of growth and development, reaching the terminal stature between the age of 18 to 25 years old. The increased stature is mainly a result of the vertical growth of the long bones such as femur, tibia, and fibula, as well as the vertebral bodies through the process of ossification. At eleven weeks prior birth, humans have 800 ossification centers on their skeletons[6]. Growth that increases the diameter of the long bone is called appositional growth. Growth through bone elongation in long bones possesses cartilagineous center called growth plates or epiphyseal plates (connecting epiphyses and metaphyses). The ossification centers have already appeared in neonatal period, and ossification (fussion of parts of bones) keeps continuing on each type of bone, until humans reach adulthood.

If the growth is ongoing or the bones have not fully ossified, line of growth is visible on that bone that is called growth plate, which is usually

TABLE 1. -Classification of stature according to anthropology

Classification	Males Vallois	Males Martin	Males Vandervael	Females Martin	Females Vandervael
Dwarf	<125	<130	<125	-	-
Very short	-	130-149.9	125-155	121-139.9	<147.5
Short	125-159.9	150-159.9	155-161	140-148.9	147.5-152.5
Sub-medium	160-164.9	160-163.9	161.5-167.5	149-152.9	153-158
Medium	-	164-166.9	168-174	153-155.9	158.5-163.5
Supra-medium	165-169.9	167-169.9	174.5-180.5	156-158.9	164-169
Tall	170-199.9	170-179.9	181-187	159-167.9	169.5-174.5
Very tall	-	180-199.9	187-200	168-186.9	>174.5
Giant	>200	>200	>200	>187	>200

Adapted from Olivier, 1969:5

horizontal. In long bones that possess heads on the proximal ends like femora and humeri, the femoral heads and humeral heads are separated from their diaphyses before they are fully ossified. In forensic cases, the skeletons of children and adolescent, growth plate area often mistakenly thought as fractures by inexperience workers. The disappearance of growth plate or line of growth marks the complete ossification of bone and the achievement of terminal stature.

Terminal stature is influenced by various factors: genetic, nutrition, environment, and stress. Terminal stature is a product of adequate nutrition and disease history[7]. Growth is influenced by various factors such as genetic, hormonal growth deficiency, and psychological stress[8]. Climate may be an intermediate factor to determine terminal stature, but stature exhibits a small correlation with latitude in many populations[9].

Amongst anthropologist and biologist, stature is a sexual dimorphic character in addition to cranial capacity, body mass index, femoral circumference, and pelvic width. Thus, anthropologist and biologist consider sexual dimorphism is a normal variation among males and females. In this case, sexual dimorphism is relative. In medical communities, however, the term of sexual dimorphism is put in an absolute context Absolute sexual dimorphism includes the composition of sex chromosom, gonade structure, hormonal state, system of internal and external genitals[10]. In the medical community, absolute sexual dimorphism is considered abnormal.

One study reports 2% frequency of absolute sexual dimorphism in various populations[11]. This 2% frequency is derived from populational survey, genetical studies, and case surveys of medical practitioner, and study of environmental population. The deviation of absolute sexual dimorphism includes androgen insensitivity in XY individuals; congenital adrenal; vaginal and penile agenesis; exogenous sexual hormons, hermaphrodite and idiopathic mixed genital. The term of sexual dimorphism referred for the stature's study here is the non-absolute sexual dimorphism or the normal metrical and non-metrical difference among males and females. Among primates, human is medium in regard to its sexual dimorphism, especially on its body size and voice[12].

Biological anthropology as a field of science studies human's biological variation, classifies stature of various populations in the world into dwarf, very short, sub-medium, medium, supra-medium, tall, very tall and giant as listed on TABLE 1. Short stature is called *chamaesome*, *medium-mesosome*, and *tall-hyposome*[3].

The aims of this study were: 1) to locate where Indonesian's stature is categorized in anthropological classification described on TABLE 1; and 2) to understand the average Indonesian's stature relative to other populations in other continents (environments). This research would contribute knowledge whether Indonesian's stature increased, decreased, or remained the same in two millenia, between 1100 A.C. and 1980-1999 A.C. Stature as one indicator of growth reflects social-economical condition, nutritional status, and environment of a population.

METHODS

The subject of study is 245 students of National University of Yogyakarta, (TABLE 2) and 47 skeletons of prehistoric Balinese. The age range

of students is between 21-25 year-old with average age of 23 years in males and 21 years in females. This data had been compiled from laboratory exercises during the years of 1980 to 1999 (TABLE 3). This date was not based on longitudinal research from the same people, but a *cross-sectional* study: on different people at certain time. Incomplete data was not used, i.e. missing sex. Stature was measured using anthropometer with the shoes taken off.

TABLE 2. -Sex distribution of Yogyakarta's National University students under study

Year of examination	Males	Females	Total
1980-1989	34	24	58
1990-1999	66	121	187
Total	100	145	245

The skeleton was derived from archaeological excavation in Bali conducted in 1963, from Gilimanuk. This skeletal population might have been fishers, based on the artifacts found such as fish coil, and kitchen midden showing fish skeletons. This material is housed at the Laboratory of Bioanthropology and Paleoanthropology Gadjah Mada University Faculty of Medicine Yogyakarta. Sex and age of the skeleton was determined using standard bioanthropological method through pelvic and cranial examinations[13,14]. Out of 47 skeletons, 35 are males and 12 are females. Age determination on the skeletons was conducted using pubic symphisis morphology[15,16]; but when pubic bone is not preserved, age estimation was determined through the degree of suture closure on latero-anterior crania[17]. The age of the skeletons range from 15 to 55 years old both in males and females. The male average age is 27 year old, and female average age is 26 year old.

Human stature is positively correlated with the length of the long bone. Thus, stature could be calculated using a regression formula. Totter and Glesser[5] defined formulas to determine stature for Mongoloid based on 92 skeletons with antermortem known stature. The regression formulas are as follow:

1.22	(Femur+Fibula)	+	70.24	+/- 3.18
1.22	(Femur+Tibia)	+	70.37	+/- 3.24
2.40	Fibula	+	80.56	+/- 3.24
2.39	Tibia	+	81.45	+/- 3.27
2.15	Femur	+	72.57	+/- 3.80
1.68	(Humerus+Ulna)	+	71.18	+/- 4.14
1.67	(Humerus+Radius)	+	74.83	+/- 4.16
2.68	Humerus	+	83.19	+/- 4.25
3.54	Radius	+	82.00	+/- 4.60
3.48	Ulna	+	77.45	+/- 4.66

The stature of the skeletons was determined using the formula above, based on the preserved long bone of each individual.

RESULTS AND DISCUSSIONS

TABLES 3 and 4 contained stature of the living and skeletal populations derived in this study. TABLE 3 lists the descriptive statistics of the National University students of Yogyakarta from the period of 1980 to 1999 in 10 years interval. From TABLES 3 and 4, it is shown that the male and female difference in stature in the National University students of 1980-1989; 1990-1999; and prehistoric Balinese circa 1000 A.C. was 11.7 cm; 12.2 cm; and 7.05 cm respectively. This difference is close to range of stature's difference between males and females, that is, females are 10-11 cm shorter than males. However, the larger difference of male and female stature in the National University students compared to prehistoric Balinese shows that the students are more sexually dimorphic than the the prehistoric Balinese.

TABLE 3 also exhibits that average male stature of students from 1980s to 1990s has increased 4 mm from 165.0 cm to 165.4 cm, while in female students, the average stature has increased 9 mm from 152.8 cm to 153.7 cm. Because stature is an indicator of growth, it is interesting that females undertook average stature higher than females in the two dekades of 1980 to 1999. This suggests positive growth norm.

The students' stature was taller compared to Indonesian's rural community such as in Rongkop and Kejajar. Stature in Rongkop (hot climate) was 158.85 cm in males and 147.45 cm in females18. Average stature in Kejajar (cool climate) is 154.28 cm in males and 144.73 cm in females[18]. Females in Rongkop was 7.18% shorter than males, while in Kejajar, females were 6.19% shorter than male[18].

TABLE 3. -Descriptive Statistics of Stature in National University Students of Yogyakarta, Year of 1980-1999.

Sex (n), periods	Mean age (min/max) year	Mean stature Cm	Stature (min) cm	Stature (max) Cm	SD
Female (121) 1990-1999	22.4 (20-25)	153.7	140.0	170.0	0.048
Male (66) 1990-1999	22.9 (21-28)	165.4	149.0	179.0	0.056
Female (24) 1980-1989	21.9 (20-24)	152.9	142.1	167.2	0.066
Male (34) 1980-1989	22.7 (20-25)	165.0	155.0	175.2	0.056

n-number of subject, min-minimum, max-maximum, SD-standard of deviation

TABLE 4. -Average Stature of Prehistoric Balinese circa 1000 A.C.

Age range 15-55 year	Mean stature	Mean age	Min. Age	Max. age
Male (n=35)	164.42 cm	27 year	15	55
Female (n=12)	157.37 cm	26 year	15	55

Other populations in the world show that female stature is 3-12% shorter than male[18]. In regard to body size, Molnar[10] reported that the range of difference between male and female was less than that of stature, about 5-10%. Other populations in the world (TABLE 5) show different percentage of stature in males and females range between 1.39% to 8.24%; where the National University students in the 1980s was 7.39%; in the 1990s was 7.07%, and in the Balinese circa 1000 A.C. is 4.32%. This percentage exhibits medium difference of male and female stature in Indonesians. In Europe and America, the difference of male and female stature is 7%, in Africa 4%, and in Asia 7%. Thus, in regard to stature, Africans is less *sexually dimorphic*, while Asian, European and American is about the same in their degree of sexual dimorphism on their stature.

Terminal stature in male is higher than female. However, before reaching terminal stature, female exceed male in stature at certain age. Spencer and Spencer[7] reported that female stature was taller than male at age of 12 years old, but at 12.5 years old and thereafter, male was taller than female. In *auxology* (growth study), this phenomenon is worldwide in many populations. One report exhibited that growth spurt in male occured later, at an average age of 13.4 years, while in females it occured at the age of 11.9 years[19]. Stature development reaches flat line in Chinese males at 171 cm and in Chinese females at 158 cm[7]. At the age of 13 years, Chinese female stature reaches 155 cm. This figure should encourage further studies on female and male growth spurt among Indonesians, and the stature difference at different ages in both sexes.

Compared to other populations in the world, Indonesians is in the medium category. TABLE 5 supports this statement, showing that Indonesians' stature is in the same range with that of Asians (Mongoloid), where male is about 160-170 cm and female about 150-160 cm. European and Caucasian (Caucasoid) male's stature is about 170-180 cm while female is about 160-170 cm. African (Negroid) exhibits high variation of stature, either inter-sex or intra-sex. So does Australian Aborigin, where male stature varies between 146 cm and 190.6 cm; and female stature varies between 137.6 cm and 174.3 cm[20].

TABLE 5 consists of compilation of average stature of worldwide populations and sexual dimorphism of stature shows minimal is 2.3 cm (1.39%) and maximal is 13.1 cm (7.48%). Indonesians in this study shows sexual dimorphism of stature is 7.1 cm (4.32%) to 12.2 cm (7.39%).

TABLE 5. Male and female stature in Europe, America, Asia, and Africa.

No.	Countries	Males (cm)	Females (cm)	Difference (%)	Periods
EUROPE AND AMERICA					
1.	Belgium	175.3	163.5	11.8 (6.73%)	1984
2.	Belgium	176.5	164.2	12.3 (6.97%)	1980
3.	Cekoslovak	178	165	13 (7.30%)	1986
4.	Denmark	179	166.6	12.4 (6.93%)	1982
5.	French	175	163	12 (6.86%)	1979
6.	Greece	174.8	160.4	14.4 (8.24%)	1970
7.	Greece	176	164	12 (6.82%)	1970
8.	Hungary	175.3	162.3	13 (7.41%)	1986
9.	Hungary	172.8	161.2	11.6 (6.71%)	1982
10.	Ireland	175.5	163	12.5 (7.12%)	1987
11.	Netherland	180.9	168.2	12.7 (7.02%)	1985
12.	Norway	180	166.7	13.3 (7.39%)	1980
13.	Poland	176.8	163.1	13.7 (7.75%)	1989
14.	Spain	175.6	161.3	14.3 (8.14%)	1985
15.	Yugoslav	175.1	162	13.1 (7.48%)	1978
16.	Yugoslav	177.6	164.5	13.1 (7.38%)	1978
17.	Argentine	172	160	12 (6.98%)	1986
18.	Brazil	172.9	159.9	13 (7.36%)	1982
19.	Chile	167.2	156.5	10.7 (6.40%)	1979
20.	Cuba	168.7	157	11.7 (6.93%)	1979
21.	Venezuela	173.4	161.2	12.2 (7.03%)	1986
22.	USA Cross	175	163	12 (6.86%)	1980
23.	USA Harvic	171	161	10 (5.85%)	1980
24.	USA P.Hill	173	161	12 (6.94%)	1925
25.	USA Mt.Gilead	172	162	10 (5.81%)	1925
26.	USA modern	174	161	13 (7.47%)	1925
27.	USA Bodwitch	177.3	169.4	11.5 (6.36%)	1875
28.	USA California	175.4	163.5	11.9 (6.78%)	1875
29.	USA Texas	175.3	162.4	12.9 (7.36%)	1929
30.	USA Wisconsin	173.4	162.4	11 (6.34%)	1929
31.	USA Minnesota	175.1	162	13.1 (7.48%)	1929
32.	USA Tennessee	175.3	162.2	13.1 (7.47%)	1929
AFRICA					
1.	Kenya	162	153	9 (5.55%)	1983
2.	Kenya	164.4	162.1	2.3 (5.6%)	1983
3.	Namibia	168.6	163	5.6 (3.32%)	1981
4.	South Africa	164.4	157.6	6.8 (4.14%)	1977
5.	Somalia	171	160	11 (6.43%)	1980
ASIA					
1.	China	167.7	157.4	10.3 (6.14%)	1988
2.	Hongkong	169.6	157.6	12 (7.07%)	1987
3.	Japan	170	157	13 (7.64%)	1987
4.	Taiwan	168.1	156.8	11.3 (6.72%)	1987
5.	Thailand	169	156.6	12.4 (7.34%)	1987
6.	India	162.2	151.7	10.5 (6.47%)	1972
7.	Indonesia-Jawa	165	152.8	12.2 (7.39%)	1980an*
8.	Indonesia-Jawa	165.4	153.7	11.7 (7.07%)	1990an*
9.	Indonesia-Bali	164.4	157.3	7.1 (4.32%)	1100*

Compiled from: Boyd[21] ; Molnar[10]; Eveleth and Tanner[9]; and *this reserach

CONCLUSIONS

1. This research shows that the average stature of the National University Student of Yogyakarta of 23 year-old average age was 1.67 meter among males and 1.55 meter among females. The average stature on pre-historic Balinese circa 1000 A.C. was 1.64 meter dan 1.57 meter on males and females respectively at average of of 27 and 26 years.

2. Anthropologically, Indonesians's stature was supra medium in males and medium in females. Both are *mesosome*, relatif to other human groups in the world.
3. The difference of Indonesian male and female stature was not significant, but sufficiently sexually dimorphic, differed between 4.32% to 7.39%.
4. Further studies need to be developed focusing on stature during growth spurt in various human groups of Indonesians.

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