ORIGINAL ARTICLE

Differences of Height Estimation Using Karl Pearson Formulation and Calculation of Multiplication Factor Using Trotter and Glesser Formulation

Ade Nahdia Nandarini[1], Anggraeni Puspitasari[1], Ahmad Yudianto[2]

[1] Forensic Science Master Program, Postgraduate School of Universitas Airlangga, 4-6 Airlangga Street, Surabaya, 60286 Indonesia
[2] Department of Forensic and Medicolegal, Faculty of Medicine, Universitas Airlangga, Jl. Mayjen. Prof. Dr. Moestopo 47, Surabaya, 60132 Indonesia

ABSTRACT

Introduction: Forensic anthropology is defined as the examination of human skeletal remains application for law enforcement to help identifying unknown skeletal findings and estimate time since death. In cases of homicides that have carried out for a long time, the bones usually left without the body's tissue. By knowing the length of the bones, we can find out a person's height to help the identification process. The aim of this study is to describe the differences of height estimation using Karl Pearson formulation and calculation of multiplication factor using Trotter and Glesser formulation. **Methods:** Samples are measured using the Karl Pearson formula and the Trotter and Glesser formula, then the results are compared with actual height. There is no statistical analysis used for this research. The results obtained from the formulas of Karl Pearson and Trotter and Glesser. **Results:** Estimated height between 156.01 cm to 164.99 cm using Karl Pearson formula, while using the calculation of the multiplication factor (MF) of Trotter and Glesser the height is estimate between 145.27 cm to 156.35 cm. **Conclusion:** Height estimation using the Karl Pearson formula is more appropriate than the calculation of the multiplication factor (MF) by Trotter and Glesser if the results compared to the actual sample height.

Keywords: Anthropology, Calculation, Forensic, Height, Karl Pearson Method, Multiplication Factor

Corresponding Author:
Ade Nahdia Nandarini, S.Si
Email: ade.nahdia.nandarini-2019@pasca.unair.ac.id
Tel: +628-993471214

INTRODUCTION

Forensic anthropology is examination of human skeletal remains that help investigators and law enforcers in identifying unknown skeletal findings (1). In cases of homicides that have carried out for a long time, the bones usually left without the body's tissue (2). Bones are usually found in remote areas, above ground level, in rivers, in swamps, in forests, or buried in shallow holes because perpetrators rush to bury the victim (3). By knowing the length of the bones, we can find out a person's height to help the identification process.

Humans have a different height from one individual to another. Human height is the measurement from the top of the head to the bottom of the plantar feet, then the length is determined. Another method is by measuring the length of specific bones such as the femur, tibia, fibula, humerus, ulna, and radius (4). The average height of Indonesians in Javanese men is 165.4 cm, and women is 153.7 cm (5). The difference in height for Javanese men and women in Indonesia is 7.39%, indicating a moderate difference (6). Among other peoples on the continent of Europe, Africa, and America. Indonesian people, including being tall (7).

Many calculations used for average height in several parts of the world, including the following Karl Pearson formula and Trotter and Glesser Formula (8). Karl Pearson formula widely used everywhere in the world since 1898 (9). Karl Pearson formula distinguishes between the male and female methods for European study subjects measured by the long dry bones such as the femur, humerus, tibia, and radius (10). We only compare each formula with the actual height result, because the two formulas are often used for estimate the height of an individual by measuring the long bones that found at the crime scene, and these two formulas only use long bones for their measurements. The actual height was known in this study. The aim of this study is to describe the differences

of height estimation using Karl Pearson formulation and calculation of multiplication factor using Trotter and Glesser formulation when compared to the actual height.

MATERIALS AND METHODS

The type of research used in this study is a comparative study. This research conducted at the Museum of Anthropology, Universitas Airlangga on April 2nd, 2018. The sample used in this study is length bones such as femur, tibia, fibula and humerus from one individual male. One individual male, with one left femur, one right tibia, one right fibula and one pair humerus bones identified. There is no statistical analysis in the methods. This research only compared both formula with the actual height. The examination method used in this study is the Karl Pearson formula (Table I) and the multifiplication factor (MF) from Trotter and Glesser formula. The results are compared with actual height of the sample. The actual height is 160 cm.

Table I : Karl Pearson Formula

No	Male	Female
1	H=81.306+1.88 x FI	H=72.844+1.945 x FI
2	H=70.641+2.894 x HI	H=71.475+2.754 x HI
3	H=78.664+2376 x TI	H=74.744+2.352 x TI
4	H=85.925+3.271 x RI	H=81.224+3.343 x RI
5	H=71.272+1.159 x (FI+T1)	H=69.154+1.126 x (FI+TI)
6	H=71.443+1.22 x (FI+1.08 x TI)	H=69.154+1.126 x (FI + 1.125 x TI)
7	H=66.855+1.73 x (HI+RI)	H=69.911+1.628 x (HI+RI)
8	H=69.788+2.769 x (HI+0.195 x RI)	H=70.542+2582 x (HI+0.281 x RI)
9	H=68.397+1.03 x FI + 1.557 x HI	H=67.435+1.339 x FI +1.027 x HI
10	H=67.049+0.913 x FI + 0.6 x TI + 1.225 x HI - 0.187 x RI	H=67.469+0.782 x FI +1.12 x TI +1.09 x HI -0.711 x RI

Notes:

H is Height Estimation (cm)
FI is Femur length (cm)
HI is Humerus length (cm)
TI is Tibia length (cm)
RI is Radius length (cm)

F1 from Karl Pearson formula in the table I is maximum length of the femur (femur), H1 is maximum length of the upper arm bone (humerus), R1 is maximum length of the collecting bone (radius) and T1 is maximum length of the shin bone (tibia).

Trotter-Glesser Formula using research subjects the male group of Mongoloid race. This formula has ten total formulas with six formulas that use each of the long bones and four other formulas with the addition of several long bones. The calculations, for example, the height of the radius bone is 3.54 x (RI) + 82.0 ± 4.6, while (RI) is the maximal length of the radius bone. Other bone calculations are the maximum length of the tibia, which is 2.39 x (TI) + 81.5 ± 3.3. The maximum length of the humeral bone is 2.68 x (HI) + 83.2 ± 4.3. The maximum length of the ulna bone is 3.48 x (UI) + 77.5 ± 4.8 to calculate two long bones you can use the calculation, namely 1.67 x (HI + RI) + 74.8 ± 4.2. Multiplication Factor (FM) calculations performed with FM from Trotter and Glesser for Mongoloid races. TB = FMaxTa (3).

Measurements were taken from the acromion located at the end of the scapula to the humeral epicondyle, the left femur measuring from the greater throcanter (superior to the epicondyal femoral), the right tibia was measured from the tuberosity point which is the very front part of the tibial bone to the medial malloulus (13).

RESULTS

The length bones identified and obtained a pair of humeral bones (Fig. 1), one left femur (Fig. 2), one right tibia (Fig. 3), and one right fibula (Fig. 4). Estimated height between 156.01 cm to 164.99 cm using Karl Pearson formula (Table II), while using the calculation of the multiplication factor (MF) of Trotter and Glesser the height is estimate between 145.6 cm to 156.35 cm (Table III).

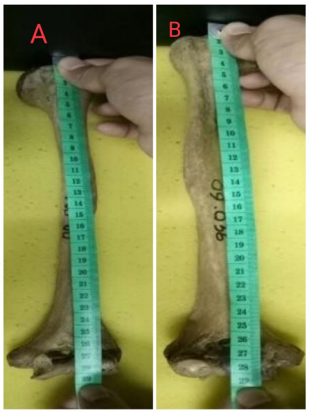

Figure 1 : Pair of Humeral Bones

Figure 2 : Right Femur

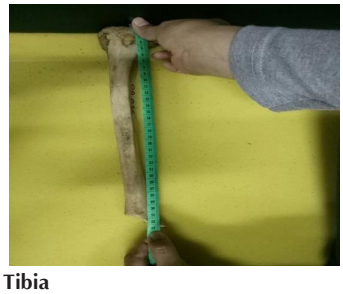

Figure 3 : Right Tibia

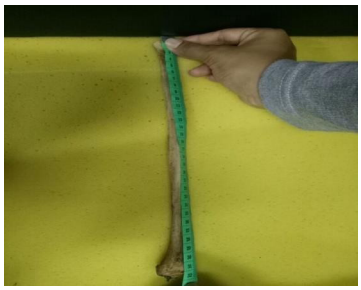

Figure 4 : Right Fibula

Table II : Height Estimation using Karl Pearson Formula

No	Height Estimation (cm)
1	H = 81.306+1.88 x 40.5 = 157.446
2	H = 70.641+2.894 x 29.5 = 156.014
3	H = 78.664+2.376 x 33.5 = 158.26
4	H = 85.925+3.271 x RI (radius bone missing)
5	H = 71.272+1.159 x (40.5+33.5) = 157.038
6	H = 71.443+1.22 x (40.5 +1.08 x 33.5) = 164.992
7	H = 66.855+1.73 x (29.5+RI) = radius bone missing
8	H = 69.788+2.769 x (29.5+0.195 x RI) = radius bone missing
9	H = 68.397+1.03 x 40.5+1.557 x 29.5 = 156.043
10	H = 67.049+0.913 x 40.5+0.6 x 33.5+1.225 x 29.5-1.087 RI = radius bone missing

Table III : Height Estimation using calculation of the multiplication factor (FM) from Trotter and Glesser

Bones	FM Mongoloid	Position	Length (T) in cm	Height Estimation = FMa x Ta (cm)
Femur	3.7	Right	Missing	-
		Left	40.5	149.85
Tibia	4.48	Right	33.5	150.08
		Left	Missing	-
Fibula	4.48	Right	32.5	145.6
		Left	Missing	-
Humerus	5.3	Right	29.5	156.35
		Left	29.5	156.35

DISCUSSION

There are 206 long bones in human to help the body for movement, including the humerus, tibia, fibula and femur (11). The measurement of height based on the long bones is one of the most widely used methods because it almost has been used in medicolegal cases. As an example of an air crash that many victims were killed, in this case the victim could not be recognized and only parts of their body were left, the identification is needed (12). The bones used in this study are one pair humerus, one left femur, one right tibia, and one right fibula.

Karl Pearson's formula was used to measure the height of men and women in a group of European people around the 1800s by measuring the length bones such as the femur, humerus, tibia and radius (14). In our study, three long bones were used (femur, tibia, and humerus), referring to the Karl Pearson formula, radius bone was not found in our study. Based on the Karl Pearson formula, there is no need fibula bones for the height measurement. Fibula only use for calculation using Trotter and Glesser formula. Number 1 in table 1 shows the height estimation using femur, number 2 is the height estimation using tibia, number 3 is the height estimation using humerus. Number 4, 7, 8 and 10 the measurement results are not obtained because the calculation in the formula uses a radius. Meanwhile, height estimation results in numbers 5, 6 and 9 are a combination of the femur, tibia, and humerus. Overall, the height estimation is ranged from 156.01 cm to 164.99 cm. The range is obtained based on the lowest and highest results shown in the table.

Height estimation using calculation of the multiplication factor (FM) from Trotter and Glesser shows in table 2. In this study, Height is measured using the femur, tibia, fibula and humerus. Only the humeral bone was found complete while the right femur, left tibia and left fibula were not found. The results are ranged from 145.6 cm to 156.35 cm. Based on the two formulas above, when compared to the actual height from the sample, the closest estimation of height is using the Karl Pearson formula, this because some parts of the bone are missing which can affect the calculation results using the multiplication factor (FM) from Trotter and Glesser. We also compare the two formulas because the two formulas use different bones, Karl Pearson formula not using fibula for the measurement.

CONCLUSION

Height estimation using the Karl Pearson formula is more appropriate than the calculation of the multiplication factor (MF) by Trotter and Glesser when compared to the actual sample height.

ACKNOWLEDGEMENT

This work is supported by Museum of Anthropology, Department of Anthropology, Universitas Airlangga, Indonesia.

REFERENCES

1. Indriati E. Antropologi forensik: Identifikasi rangka manusia, aplikasi antropologi biologis dalam konteks hukum. Yogyakarta: Gadjah Mada University Press; 2010.
2. Franklin D. Forensic estimation in human skeletal remains: Current concepts and future directions. Legal Medicine. 2010: 12(1): 1-7.
3. Hidayat T, Susanti R. Analisis antropologi forensik pada kasus penemuan rangka di dalam koper.

Pertemuan Ilmiah Tahunan. 2017: 281-285.
4. Handayani, Purwani T, Prima A. Panjang tulang femur dapat menjadi penentu tinggi badan pria dewasa muda. Jurnal Kedokteran Syiah Kuala. 2014: 14(1): 38-42.
5. Muljati S, Winarto A, Utami N, Hermina. Gambaran median tinggi badan dan beraat badan menurut kelompok umur pada penduduk Indonesia yang sehat berdasarkan hasil RISKESDAS 2013. Penelitian Gizi dan Makanan. 2016: 39(2): 137-144.
6. Wulan A, Wilujeng ID. Korelasi antara panjang tulang radius dengan tinggi badan pada pria dewasa suku Lampung dan suku Jawa di kecamatan Gisting kabupaten Tanggamus. JK Unila. 2018: 2: 14-19.
7. Tarrant MTAT, Shirley NR. Forensic anthropology an introduction. USA: CRC Press; 2013.
8. Maulana R. Estimasi tinggi badan berdasarkan panjang tulang tibia dan radius secara perkutan pada laki-laki etnis Cina di SMAK St. Hendrikus Surabaya. Surabaya: Universitas Airlangga; 2002.
9. Christensen AM, Passalacqua NV, Batelink EJ. Forensic anthropology current methods and practice. USA: Elsevier; 2014.
10. Glinka J, Artaria MD, Koesbardiarti T. Metode pengukuran manusia. Surabaya: Airlangga University Press; 2008.
11. Astini DAAAS, Sana IGNP, Widarsa IKT, Sueta IN, Suwitra IW, Trisna SK. Perkiraan tinggi badan berdasarkan tulang panjang usia 17-22 tahun. Warmadewa Medical Journal. 2017: 1(2): 66.
12. Wilujeng ID. Korelasi antara panjang tulang radius dengan tinggi badan pada pria. J Agromed Unila. 2015: 2: 170–174.
13. Fhierhasbyantara H. Aplikasi rumus tinggi badan trotter dan glesser pada anggota inti unit kegiatan mahasiswa sepak bola divisi futsal putra universitas airlangga dan institut teknologi sepuluh november. Surabaya: Universitas Airlangga; 2018.
14. Praveen A, Vijayanath V, Vijaya NM, Anjanamma TC. Estimation of stature from fragments of femur. Indian Journal of Forensic and Community Medicine. 2016: 3(3); 225-229.