Metric Study by Biometric Information for Individual Identification of Unknown Human Skeletal Remains

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Abstract. The biometric information is very important for individual identification of unknown human skeletal remains. Sex determination of the unknown human skeletal remains is the first step to determine the individual identification. We have collected the biometric information of cadavers to make physical anthropological data in Koreans. The studies until now showed the necessary of the different methods for specific population groups, and therefore we would make the collection of biometric information of Koreans.

Keywords: identification, forensic anthropology, metric study, bones, CT image

1 Introduction

Forensic anthropology is one of the forensic sciences and the field study that deals with the analysis of human skeletal remains. It is based on physical anthropology and is study of skeletal material that comes under the jurisdiction of law enforcement [1]. In addition, the necessary of positive identification is emphasized because the victim of crime, accident, and mass disaster is increasing recently. Therefore, physical anthropological data is need for accurate individual identification [1,2]. Forensic anthropologists attempt to determine ancestry, sex, age, and living height from the human skeletal remains. Sex determination is an early important step in the analysis of skeletal remains. There are two major methods of sex determination: metric and non-metric [3,4]. Metric analysis is more precise than non-metric analysis and provides statistical weight and advantageous for forensic anthropologists who are new to the field. Therefore, they prefer metric method to non-metric method because the results of metric method also get recognized in court [4,5]. Many researchers have studied human skeletons to determine sex by metric method and mention the need of various equations for which is diverse population groups [6-12]. For Korean subjects, there have been studies on sex determination using the mandible [13], the pelvis [14], teeth [15], and the talus [4].

This study presented studies of authors for individual identification until now, primarily sex determination. We thought this presentation should be helpful to understand importance of forensic anthropology and data collection by biometric information, and the need of various methods according to population groups.

2 Materials and Methods

We used bones and three-dimensional reconstructed CT images for study and measured by a digital vernier caliper (MyCAL Absolute 500-652, Kawasaki, Mitutoyo, Japan) and a computer program (Mimics Version 13.1, Materialise, Belgium and V-Ceph Version 3.0, Cybemed, Korea). The data were also analyzed computer program (SPSS Version 17.0, SPSS Inc., Chicago, IL, USA).

2.1 Frontal sinus

These were taken from the Digital Korean Human Model Database (http://digitalman.kisti.re.kr) at Korea Institute of Science and Technology Information. The ages ranged from 21 years to 72 years and the mean age was 52 years.

The frontal sinuses were reconstructed and measured by a computer program (Mimics Version 13.1, Materialise, Belgium). After 3-D reconstruction, the frontal sinus was cut from under the baseline. The “baseline” was a line drawn horizontally along the upper margin of the orbit and parallel to the Frankfort horizontal plane. Four non-metric and 13 metric methods were measured after the frontal sinus was cut from the baseline. The metric and non-metric data were analyzed using an SPSS (Version 17.0, SPSS Inc., Chicago, IL, USA) subroutine package. The 4 non-metric and 2 metric items are represented by a total of ten digits. Each section is described by two digits, except BAI, and distinguished by a forward slash. The digits in each section are divided into right and left frontal sinuses.

2.2 Hyoid bone

The hyoid bones of 85 Korean cadavers of known sex and age were extracted. The mean age of the cadavers at death was 52 years. We had carefully separated the hyoid bone from the thyroid cartilage and removed adherent tissue. We took 33 measurements using a computer program (V-Ceph Version 3.0, Cybermed, Korea) following photography with a digital camera. The data were subjected to direct discriminant function analysis using an SPSS (version 11.0, SPSS Inc., Chicago, IL).

2.3 Ribs

The sample comprised complete dry ribs of 54 individuals for which sex and age at death were known. We used specimens with complete sets of ribs 2 through 9 and measured each of the three variables twice with digital vernier calipers (MyCAL Absolute 500-652, Kawasaki, Mitutoyo, Japan). The values for the three metric variables were analyzed using SPSS (version 13.0, SPSS Inc., Chicago, IL, USA). The three variables were as follows: 1. The articular facet of the tubercle-to-angle length (AFTAL)-the distance from the most vertebral edge of the articular facet of the tubercle to the angle, a roughened oblique line on the external surface of the rib, which is the attachment site for the iliocostalis muscle. 2. The head-to-articular facet length (HAFL)-the distance from the medial edge of the head to the most lateral border of the articular facet, which is always clearly identifiable. 3. The superior costo-transverse crest height (SCTCH) measured on the neck of the rib -the maximum distance from the inferior surface of the neck of the rib to the peak of the rib crest.

3 Results

3.1 Frontal sinus

In nine cadavers (7.6%) among 119, the frontal sinuses were not found; 4 male cadavers and 5 female cadavers. The frontal sinus was found on only one side in 18 cadavers (15.1%). Fused sinuses and a prominent middle of fused sinus were found in 52 of 119 cadavers (43.7%). A statistically significant difference between sexes was found in the right frontal sinus shape in the anterior view, as well as in the outline of the upper border, the right sinus shape in the lateral view with the outline of upper border, and then in the left sinus shape in the anterior view with angle in superior view ($P < 0.05$). Among thirteen measurements, total volume showed a statistically significant difference between sexes ($P < 0.05$). All measurements but 3 were larger in the males than in females (Table 7). The three measurements that were larger in female than male were not statistically significantly different between the sexes. Those were: width of fused and right sinuses, and distance between both sinuses. Two among 110 cadavers had the same digit code. Four figures show one, both, fused, and prominent middle sinuses, and explain the digit code.

3.2 Hyoid bone

Male hyoids were larger than females in 21 of 33 measurements ($P < 0.05$). Twenty of the 33 measurements showed statistically significant sex differences by independent sample t-tests. It is observed that the distinction ability of discriminant function was high (0.72) and Wilk's lambda was 0.000, which meant that it was statistically in significance level 5%. In the standardized canonical discriminant function coefficients, the 6th measurement, the length of the hyoid body was 0.577, high in relative explanation power among the group of 3 variables.

Non-standardized canonical discriminant function in which average of group centroid is 0.235. If the result of the discriminant function above is over 0.2, the sample is male, and if under 0.2, female.

Fisher's linear discriminant function is formed by group and a new object is classified into the group which has large value after its independent variables are inserted and calculated in classification function. It is observed that coefficient of classification function of these 3 variables is high. As the result of classification, 78 out of 85 objects were classified correctly. Its accuracy was 88.2%.

3.3 Ribs

The three variables of each rib differed significantly between the sexes in independent sample t tests ($P < 0.05$) and most measurements did not differ significantly between the right and left sides ($P > 0.05$), except for the SCTCH in ribs 6, 8, and 9.

Discriminant function analysis was calculated three ways based on rib numbers and variables. For AFTAL of all ribs, the ability of the discriminant function was 0.417, Wilks's lambda was 0.826 ($p < 0.001$), and the discriminant variable was rib 4 only. The accuracy of the discriminant function analysis was 75.2%. Using HAFL of all ribs, the accuracy was 75.2%, and the discriminant variables were ribs 2 and 7. In SCTCH of all ribs, the discriminant variables were ribs 2 and 4, and the accuracy was 86.1%. In AFTAL with SCTCH of all ribs, the discriminant variables were ribs 2, 3, 4, and 7, and the accuracy was 89.1%, which is the highest of the values calculated. Using each variable from ribs 2 to 4, the discriminant variables were AFTAL of rib 4, HAFL of rib 2, and SCTCH of ribs 2 and 4, and the accuracy was 88.1%. The accuracy of AFTAL with SCTCH was the highest of all the variables, and the discriminant variable of AFTAL was the simplest to obtain and had acceptable accuracy.

4 Discussion

Positive identification involves matching of an "unknown" individual to a "known" individual [16]. The identification of skeletal and other decomposed human remains is very important for legal and humanitarian reasons. Moreover, sex determination is the main objective. Basing sex determination on the shape of skeletal features can lead to divergent opinions according to individual experiences. Thus, an impartial metric method for sex determination is essential [3].

The accuracies were 88.2% using the hyoid bone, 75.2 ~ 89.1% using the ribs, 67.1 ~ 87.1% using the talus [3], 60% using the pelvis. In frontal sinus, 2 among 110 cadavers (1.8%), which were those that had the frontal sinus, had the same digit code. Such as the results, we thought these methods should be helpful to determine individual identification of Koreans.

Many authors [3,4,6-12] mentioned the different characteristics of bones in the population groups. In the frontal sinus, the difference among populations is best illustrated by the bilateral absence. The frequency of bilateral absence from Korean population was 6.7% in men and 8.5% in women, differed from Japanese population (13% in men and 23% in women). That in the Eskimo population was higher than that in other population even over 40%. In the hyoid bone and ribs, some variables of Korean were larger than of other populations. The reason for this difference might be explained as an environmental factor, genetics, habitual behavior, and variations in stature [10]. Such as difference, the divergent methods must be needed specifically for different population groups. The biometric data collection is very important to make the divergent methods for identification of Korean people.

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