Determination of Stature from Anthropometric Measurements of Thyroid Cartilage in the Population of Punjab

Sunil Subramanyam¹, Dalbir Singh², YS Bansal³, SP Mandal⁴

¹Associate Professor, Department of Forensic Medicine, Pondicherry Institute of Medical Sciences, Ganapathichettikulam, Pondicherry, ²Professor, Department of Forensic Medicine, Adesh Medical College and Hospital, Kurukshetra, ³Professor & Head, ⁴Professor, Department of Forensic Medicine, Post Graduate Institute of Medical Education and Research, Chandigarh

Abstract

The astonishing task of determining the identity of an individual has been simplified, with the innovation of scientific technologies like DNA fingerprinting in the developed countries. Yet the application of such advanced technologies in developing countries is still a daunting task due to its complexity. Anthropometric analysis for the identification of unknown bodies is reasonably productive owing to its inexpensiveness. The aim of this study was to correlate the anthropometric measurements of the thyroid cartilage with the stature of the individual. Thyroid cartilages from 300 post mortem cases done in native population of Punjab were studied anthropometrically. A total of seventeen anthropometric measurements of selected parameters of thyroid cartilage were defined, measured, and statistically correlated with the body length of the individual. The variables which were significantly correlating with the body length were further analysed by regression analysis for derivation of a regression equation.

Key words: Anthropometric measurements, Regression analysis, Stature determination, Thyroid cartilage.

Introduction

One of the most important duties of any forensic expert is to determine the identity of an unknown deceased and establishing the same from any dismembered part of body. Stature of an individual is an essential requirement for establishing the identity of the individual. Most of the previous studies have relied on the anthropometric measurements of long bones for identifying the stature of an individual. The various well defined anatomical features of thyroid cartilage are not only quantifiable as anthropometric measurements (¹) but it also has an added advantage of being in a superficial anatomical location that negates the tedious removal and preparation process that must be done when utilising long bones for stature estimation. There are a few literatures (²-⁶) that estimates the stature of individual using anthropometric measurements of thyroid cartilage, which are done exclusively within a target native population. The aim of this study was to determine the stature from the anthropometric measurements of the thyroid cartilage in native population of Punjab.

Objectives:

1. To establish correlation between the anthropometric measurements of thyroid cartilage and the body length of the deceased.
2. To derive regression equation for estimation of stature from significantly correlating anthropometric measurements of thyroid cartilage.

Materials and Method

Materials used:

Portable anthropometer, Vernier caliper and Goniometer were used for the present study.

Method:
It is a prospective analytical study conducted from July 2012 to December 2013 on 300 cases autopsied in the department of Forensic Medicine of a tertiary care hospital in Chandigarh. Written informed consent from the legal heirs of the deceased were taken.

**Inclusion criteria**
- All cases above the age of 18 years.
- Residents of Punjab having at least two generation of ancestors from Punjab.

**Exclusion criteria**
- Cases with injury to thyroid cartilage.
- Known cases of Kyphosis
- Known cases of Scoliosis
- Acromegaly.
- Gigantism.
- Cretinism.
- Dwarfism.
- Congenital abnormalities of neck.
- Cases with advanced decomposition changes.

The recumbent length of the deceased was measured with the help of portable anthropometer after extending the neck, spine, and the lower limbs to overcome flexion due to rigor mortis. The body length was measured from vertex to the heel of the foot. To avoid inter observer error, the measurements were measured by three different observers and the mean value was taken. The thyroid cartilage was dissected out during autopsy, with great care as not to damage the superior and inferior horns in the process. The entire thyroid cartilage was then soaked in warm caustic soda solution until all muscular and ligamentous attachments sloughed off. After removal of all attachments, the dimensions of the thyroid cartilage were measured with the help of a thread, vernier caliper and goniometer. The recumbent body length and 17 parameters including the thyroid angle of thyroid cartilage were measured as per Table 1. All the parameters were measured by three observers and the mean value was taken as the final measurement to avoid inter observer error of measurement. All the analyses were carried out with the help of IBM SPSS Statistics package (version 20.0).

**Results**

A total of 300 samples of thyroid cartilages of the deceased belonging to Punjab population were collected and studied. Of these 300 samples, 238 were males and 62 were females. The length of body varied from 146 cm to 195 cm in males with a mean of 169.95 cm, mean standard deviation of 7.16 cm and standard error of 0.46. In females, body length ranged from 144 cm to 184 cm with a mean of 156.59 cm, mean standard deviation of 8.06 cm and standard error of 1.02. The length of body was compared and correlated with each of the seventeen variables using bivariate correlation analysis. A significant positive correlation was obtained between the body length of male and female with the length of both the sides of thyroid lamina with Pearson correlation value of $r > 0.8$ as shown in the table 2A, 2B, 2C.

In males:
- $L_{RTL}$ was correlating with the length of body with Pearson correlation of $r = 0.908$.
- $L_{LTL}$ was correlating with the length of body with Pearson correlation of $r = 0.895$.

In females:
- $L_{RTL}$ was correlating with the length of body with Pearson correlation of $r = 0.959$.
- $L_{LTL}$ was correlating with the length of body with Pearson correlation of $r = 0.953$.

Regression equation for prediction of body length of male and female was obtained from length of right and left thyroid lamina with standard error of estimate of 2.87 (male) and 2.89 (female)

**MALE:**

$$\text{Body length} = 97.087 + 7.481(L_{RTL}) - 4.822(L_{LTL})$$

**FEMALE:**

$$\text{Body length} = 93.119 + 7.851(L_{RTL}) - 4.919(L_{LTL})$$
Table 1: Points of measurement for each parameter and units of measurements:

| S. No | Parameters                                      | Points of measurements                                      | Units of measurements |
|-------|-------------------------------------------------|--------------------------------------------------------------|-----------------------|
| 1     | Recumbent body length                           | Vertex of head to heel of feet                                | Centimetre            |
| 2     | Length of right thyroid lamina (L RTL)          | Midpoint of upper border of right thyroid lamina to          | Millimetre            |
|       |                                                 | Midpoint of lower border of right thyroid lamina             |                       |
| 3     | Length of left thyroid lamina (L LT L)          | Midpoint of upper border of left thyroid lamina to           | Millimetre            |
|       |                                                 | Midpoint of lower border of left thyroid lamina              |                       |
| 4     | Breadth of right thyroid lamina (B RT L)        | Anterior thyroid prominence to Midpoint of posterior border  | Millimetre            |
|       |                                                 | of right thyroid lamina                                      |                       |
| 5     | Breadth of left thyroid lamina (B LT L)         | Anterior thyroid prominence to Midpoint of posterior border  | Millimetre            |
|       |                                                 | of left thyroid lamina                                       |                       |
| 6     | Ventral thyroid height (V HT)                   | Deepest point of Superior thyroid incisura to Prominent point of Inferior thyroid incisura | Millimetre            |
| 7     | Dorsal right thyroid height (DR RT HT)          | Tip of right superior horn to Tip of right inferior horn     | Millimetre            |
| 8     | Dorsal left thyroid height (DR LT HT)           | Tip of left superior horn to Tip of left inferior horn       | Millimetre            |
| 9     | Upper thyroid breadth (U BR)                    | Outermost point of base of right superior thyroid horn to    | Millimetre            |
|       |                                                 | Outermost point of base of left superior thyroid horn        |                       |
| 10    | Lower thyroid breadth (L BR)                    | Outermost point of base of right inferior thyroid horn to    | Millimetre            |
|       |                                                 | Outermost point of base of left inferior thyroid horn        |                       |
| 11    | Maximum thyroid Breadth at superior thyroid tubercle (B S TB) | Outermost prominent point of right superior tubercle to Outermost prominent point of left superior tubercle | Millimetre            |
| 12    | Maximum thyroid Breadth at inferior thyroid tubercle (B I TB) | Outermost prominent point of right inferior tubercle to Outermost prominent point of left inferior tubercle | Millimetre            |
| 13    | Length of right superior horn (RTS HR)          | Tip of right superior horn to Base of right superior horn    | Millimetre            |
| 14    | Length of left superior horn (LT S HR)          | Tip of left superior horn to Base of left superior horn      | Millimetre            |
| 15    | Length of right inferior horn (RT I HR)         | Tip of right inferior horn to Base of right inferior horn    | Millimetre            |
| 16    | Length of left inferior horn (LT I HR)          | Tip of left inferior horn to Base of left inferior horn      | Millimetre            |
| 17    | Depth of superior thyroid notch (DEPTH)         | Highest level of thyroid lamina to Deepest point of superior thyroid notch | Millimetre            |
| 18    | Angle of thyroid (ANGLE)                        | Posterior surface of right lamina to Posterior surface of left lamina | Degree               |
Table 2 A: Mean, SD, correlation of body length with thyroid cartilage measurements.

| Gender | Age | Body Length (cm) | L RT L (mm) | L LT L (mm) | B RT L (mm) | B LT L (mm) | V HT (mm) | DR RT L HT (mm) |
|--------|-----|-----------------|-------------|-------------|-------------|-------------|-----------|-----------------|
| Male   | 238 | 39.24           | 169.95      | 27.42       | 27.43       | 36.50       | 36.48     | 16.48           | 34.85           |
|        |     | ±13.63          | ±7.16       | ±2.47       | ±2.49       | ±7.56       | ±7.49     | ±2.90           | ±7.59           |
|        |     | Correlation with body length, r | 0.908 ** | 0.895 ** | -0.007ns | -0.008ns | 0.220** | -0.005ns |
| Female | 62  | 40.95           | 156.59      | 21.58       | 21.58       | 32.44       | 32.52     | 14.04           | 34.41           |
|        |     | ±16.35          | ±8.06       | ±2.75       | ±2.82       | ±8.18       | ±8.21     | ±2.20           | ±8.39           |
|        |     | Correlation with body length, r | 0.959 ** | 0.953 ** | 0.173** | 0.170** | 0.445** | 0.05ns |

**p value <0.01, *p value <0.05, ns - p value >0.05

Table 2 B: Mean, SD, correlation of body length with thyroid cartilage measurements.

| Gender | Age | Body Length (cm) | DR LT HT (mm) | U BR (mm) | L BR (mm) | B S TB (mm) | B I TB (mm) | RT S HR (mm) |
|--------|-----|-----------------|---------------|-----------|-----------|-------------|-------------|--------------|
| Male   | 238 | 39.24           | 169.95        | 34.87     | 45.76     | 38.70       | 45.74       | 29.52        | 16.11          |
|        |     | ±13.63          | ±7.16         | ±7.66     | ±7.514    | ±5.96       | ±7.61       | ±5.29        | ±4.55          |
|        |     | Correlation with body length, r | -0.012ns | -0.04ns | 0.022ns | 0.024ns | 0.015ns | -0.023ns |
| Female | 62  | 40.95           | 156.59        | 34.58     | 45.39     | 38.54       | 45.37       | 29.27        | 15.80          |
|        |     | ±16.35          | ±8.06         | ±8.61     | ±8.64     | ±7.77       | ±8.68       | ±6.20        | ±4.97          |
|        |     | Correlation with body length, r | 0.042ns | -0.010ns | 0.013ns | -0.001ns | 0.016ns | -0.004ns |

ns - p value >0.05

Table 2 C: Mean, SD, correlation of body length with thyroid cartilage measurements.

| Gender | Age | Body Length (cm) | LT S HR (mm) | RT I HR (mm) | LT I HR (mm) | DEPTH (mm) | ANGLE (deg) |
|--------|-----|-----------------|--------------|--------------|--------------|------------|-------------|
| Male   | 238 | 39.24           | 169.95       | 16.62        | 10.37        | 10.38      | 10.21       | 83.88        |
|        |     | ±13.63          | ±7.16        | ±4.70        | ±2.67        | ±2.59      | ±3.45       | ±11.38       |
|        |     | Correlation with body length, r | -0.0210ns | -0.040ns | -0.030ns | 0.011ns | 0.006ns |
| Female | 62  | 40.95           | 156.59       | 16.00        | 9.80         | 9.79       | 10.71       | 87.53        |
|        |     | ±16.35          | ±8.06        | ±4.52        | ±2.47        | ±2.42      | ±2.87       | ±12.89       |
|        |     | Correlation with body length, r | 0.000ns | 0.012ns | 0.025ns | -0.005ns | -0.133* |

*p value <0.05 ns - p value >0.05
Discussion

Various studies, which analysed the anthropometric measurements of thyroid cartilage of males and females, found a significant difference between them and established that sex can be determined from anthropometric measurements of thyroid cartilage (7-15). In the present study, the body length of the deceased was compared with various parameters of thyroid cartilage and it was found to be significantly correlating with length of right and left thyroid lamina for both gender. This finding was consistent with the studies conducted by Monica and Dhall (2) and Pierre Fayoux et al (3). The study conducted by Monica and Dhall (2) also found a significant correlation between body length of individual with height of arch of cricoid cartilage and transverse diameter of cricoid cartilage. In the present study those anthropometric parameters were not measured. The study conducted by Pierre Fayoux et al (3) done on 300 human larynxes also found significant correlation with thyroid alar width, and median anterior thyroid height. Whereas the present study didn’t find any correlation of body length with thyroid alar width and median anterior thyroid height. Too-Chung and Green (4) conducted a study in paediatric age group with 67 samples. They reported a linear correlation between body length with coronal and sagittal diameter at lower border of cricoid cartilage whereas the present study, the anthropometric parameters like coronal and sagittal diameter of lower border of cricoid cartilages were not evaluated. The study conducted by Schild (5) was conducted on human infant larynxes and found a linear correlation between crown rump length and the ventral thyroid height, but in the present study the parameter ventral thyroid height was not correlating with the body length. The study conducted by Ajmani et al (6) didn’t find any correlation between various anthropometric measurements of thyroid cartilage and the body length of the individual. The deviations of the above study results from the present study might be due to variation in the definition of parameters studied, differences in the number of samples and age range of samples studied from the present study.

Conclusion

Significant correlations were found between length of both sides of thyroid lamina and body length in both gender. Regression equation for prediction of body length from length of right and left thyroid lamina was derived for each sex. With a sample of thyroid cartilage of known gender, one can estimate the body length of the individual using the regression formula we have derived. This regression formula uses only the major parameters of thyroid cartilage namely length of right and left thyroid lamina, which are less prone to be damaged in the process of recovery from the body compared to other parts of thyroid cartilage. Further studies need to be conducted in different population to derive a standard regression equation for estimation of stature from anthropometric measurements of thyroid cartilage for a native population.

Conflict of Interest: Nil

Source of Funding: Self

Ethical Clearance: The ethical clearance was taken for the present study from the institute ethical committee.

References

1. Williams PL, Warwick R, Dyson M, Bannister LH. Gray’s Anatomy. 37th Ed. Edinburgh, Churchill Livingstone, 1989;1250-51
2. Monica J, Usha D. Morphometry of the thyroid and cricoid cartilages in adults. J Anat Soc India. 2008; 57:119-123.
3. Fayoux P, Marciniak B, Devisme L, Storme L. Prenatal and early postnatal morphogenesis and growth of human laryngotrapeal structures. J Anat. 2008; 213:86-92
4. Too-Chung MA, Green JR. The rate of growth of cricoid cartilage. J Laryngol and Otol 1974; 88:65-70.
5. Schild JA. Relationship of laryngeal dimensions to body size and gestational age in premature neonates and small infants. Laryngoscope. 1984; 94:1284-92
6. Ajmani ML, Jain SP, Saxena SK. A metrical study of laryngeal cartilages and their ossification. Anat Anz. 1980; 148:42-8.
7. Maue WM, Dickson DR. Cartilages and ligaments of the adult human larynx. Arch Otolaryngol. 1971; 94:432-39.
8. Ajmani ML. A metrical study of the laryngeal skeleton in adult Nigerian. J Anat. 1990; 171:187-91.
9. Harjeet, Jit I. Dimensions of the thyroid cartilage in neonates, children and adults in north west Indian subjects. J Anat Soc India. 1992; 41:81-92.
10. Eckel HE, Sittel C, Zorowka P, Jerke A. Dimensions of the laryngeal framework in adults. Surg Radiol Anat 1994; 16:31-6.
11. Sprinzl GM, Eckel HE, Sittel C, Pototschnig C, Koebke J. Morphometric measurements of the cartilaginous larynx: An anatomic correlate of laryngeal surgery. Head Neck. 1999; 21:743-50.
12. Zielinski R. Morphometrical study on senile larynx. Folia Morphol. 2001; 60:73-8.
13. Pereira J G, Zaquia L H., Pereira Da C F O, Fisch P, Coelho M R, Cervantes O. The asymmetry index of the cricoid cartilage and the external angle of the thyroid cartilage. A sex-related study. Eur J Anat. 2007; 11:1-7.
14. Monica J, Usha D. Morphometry of the thyroid and cricoid cartilages in adults. J Anat Soc India. 2008; 57:119-123.
15. Longia GS. Anthropometrical features of laryngeal cartilages. J forensic Med (Istanbul). 1990; 6:141-8.