Age Estimation

1.0 Principle, Spirit and Intent

This section presents methods utilized in age estimation. Such methods are usually applied in forensic anthropology to estimate age at death in deceased individuals, especially skeletal remains, but aspects can also be applied to assessing age in living individuals. Estimates of age are important because they can be compared with antemortem records or other information to contribute to the identification process or help resolve other medico-legal issues, such as evaluation of age of living individuals in immigration cases. The methods should be employed with a spirit of scientific integrity: subjective interpretation should be limited, scientifically tested methods should be used, where possible, and method weaknesses and limitations should be communicated.

2.0 Purpose and Scope

Selection of methods to be employed in age estimation depends upon the materials available for examination, their condition and the age category of the individual. Analysis of fetal, infant, child, adolescent and adult remains may involve varied methodology, including gross examination, the use of radiographic techniques and histological approaches. These guidelines recommend approaches for estimating age depending on the age category. In the absence of specific guidelines or procedures, the principle, spirit and intent should be met.

3.0 General Principles

Age estimation involves first assessing physiological age and then attempting to correlate it with chronological age. The developmental or degenerative traits used as age standards undergo sequential chronological change. The traits represent the stages of physiological age for an individual. These traits are observed and documented in modern individuals of known chronological age, sex and ancestry. Correlations can be made between the traits that define physiological age and the chronological age of the known individuals. If correlations are strong, this information can be extended to estimate the age of unknown individuals of similar sex and/or ancestry. Such applications assume that the process occurs in the same order and at the same rate in both groups. The influence of the original reference sample's age composition on the estimated age of the skeleton(s) of interest (i.e., age mimicry) may represent a complicating factor. This occurs when the age representation of the reference sample is deficient in part of the lifespan, so the distributions of particular age-informative traits are not the same in the skeletal sample and the living population.

Acceptable age indicators fulfill four criteria: 1) morphological changes proceed unidirectionally with age; 2)features have a high correlation with chronological age; 3) changes occur roughly at the same age in all individuals (at least within a distinguishable subgroup); and 4) the characteristics are measured or classified with known intra- and interobserver error rates.

Whenever possible, standards for age assessment should be used that are most appropriate for the ancestry/population origin of the remains examined. Both sex-based and ancestry-based variation exists in dental and osteological development. When population-specific standards are not available, standards that are more inclusive (and with greater variance) should be used, and those standards should be documented in the report.

Practitioners should have extensive knowledge of skeletal anatomy and experience with the various methods of age estimation. This includes both experience in the technique used during age estimation, as well as experience with osteological material. The analyst should be knowledgeable about the ranges of normal human variation in the teeth and skeleton. They should be attentive to pathological conditions that might have an effect on traits used for aging purposes, especially degenerative changes.

Experience is important in assessing multiple age indicators in adults, although statistical approaches can be useful as well. See the SWGANTH statistics guidelines for more information. The final age estimate is a matter of expert judgment by synthesizing all available information. Factors to be considered are: appropriateness of the reference data, skill in using one method over another, condition of the remains, compatibility/incompatibility of statistical models, etc.

4.0 Considerations and Approaches for Analyzing Immature Remains

When and if teeth are present they should be assessed for their stage of development. Dental development has been demonstrated to reflect chronological age more closely than osteological development. Dental development appears to be under stronger genetic control, while osteological development is more influenced by environmental factors such as biomechanics, physiological stress and nutrition.

Age estimates generated from the assessment of dental development are more reliable than those derived from the assessment of dental eruption. Significant variation exists among eruption times and the order of eruption in infants and children.

Dental development is a more reliable means of estimating age than epiphyseal appearance and union.

Development in females occurs earlier than in males. The extent and nature of this difference varies among different populations.

Epiphyseal union is more important than appearance for practical reasons. Small, incompletely mineralized lumps of bone are often poorly preserved, difficult to recognize in the field during recovery operations and hard to identify as specific bones. Often, with fresh cases, maceration of the body is not feasible and, therefore, radiographic assessment of the appearance of secondary ossification centers is important.

The timing and sequence of epiphyseal union vary considerably among individuals. Several years can elapse between initial and final epiphyseal closure. For this reason, evaluation should consider the extent of closure. Different epiphyses provide different levels of accuracy and precision in estimating age at death.

Gross inspection of bones can yield different information than radiographic assessment for the appearance of ossification centers and for epiphyseal union.

While bone dimensions provide some indication of age, they are strongly affected by ancestry and life history, specifically growth retardation from poor health, including malnutrition.

The following approaches are recommended for specific age categories:

4.1 Fetal

Since dental development is minimal in fetal remains, most estimates of age rely on bone formation, especially long bone lengths but also other bones such as the assessment of the development of the ilium and the petrous portion of the temporal. If accurate measurements can be taken, formulae exist to allow the calculation of body length and subsequently age. If developing teeth are present and can be correctly identified as to type, they can provide useful information as well.

4.2 Neonatal, Infant, and Child

If accurate assessment of dental development is possible, this method should be given more emphasis in age estimates. In the absence of dental information, assessments of skeletal maturation (including long bone lengths and maturation of other skeletal elements) can be used.

4.3 Adolescent

In addition to skeletal measurements and dental evaluation, the extent of formation and union of epiphyses is important. Epiphyseal evaluation involves gross examination in skeletal remains and radiological assessment in fleshed material.

5.0 Considerations for Analyzing Mature Remains

Age estimation evaluation of adults can include examination of epiphyseal closure and dental development in younger adults, but methods generally involve assessment of degenerative skeletal changes and other features, including microscopic bone structure and dental features. Some methods for estimating age at death are more reliable for particular periods of adult life. Factors of the environment and life history of the individual can introduce non-age related variation in the expression of degenerative traits and thus represent a potential source of error. Most research suggests that for adults, consulting multiple age indicators provides more accurate results than using single indicators.

6.0 Variation and Uncertainty

In estimating age at death, it is important to be cognizant of the limitations of the various methods utilized.

Some specific methods are more prone to produce biased age estimates than others for statistical reasons and the nature of the original reference samples. Proper documentation of the variation/error involved should be provided.

Younger individuals can in general be aged more accurately than older individuals. With increasing age, the variation produced by environmental factors and life history increases.

7.0 Unacceptable Practices

Practitioners should not report overly precise age estimates without providing a proper documentation of the variation/error involved.

Practitioners should not report age estimations without giving appropriate attention to sex and population factors.