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Standard for Age Estimation in Forensic Anthropology

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AAFS Standards Board

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Foreword

~~This standard was revised, prepared, and finalized by the Anthropology Consensus Body of the AAFS Standards Board (ASB). The Anthropology Subcommittee of the Organization of Scientific Area Committees (OSAC) under the guidance of the National Institute of Standards and Technology (NIST) recognizes age estimation as an important component of the biological profile and has used the document initially published by the Scientific Working Group of Forensic Anthropology (SWGANTH).~~

This document is intended to assist forensic anthropologists when estimating age from complete or partial human skeletal material. Age is one of several biological parameters that can be estimated from skeletal material or ~~radiographic images of skeletal elements.~~medical imaging. Age estimation is based on a relationship between biological changes to the skeleton and time, either through the subadult period encompassing growth and development of the skeletal system, or the adult period encompassing the end of development and skeletal degeneration. The interplay between age estimation and the rest of the biological profile is complex. ~~Age estimation serves~~In some cases age estimation can serve as a foundation for developing other essential estimates of a biological profile. ~~Accurate and valid~~In others, age estimation ~~is dependent upon accurate estimates~~accuracy in certain parts of ~~other biological parameters, such as~~the lifespan may be improved through the use of ancestry ~~and~~or sex~~.~~ specific methods.~~The interplay between age estimation and the rest of the biological profile is complex.~~

In the forensic setting, the estimated age interval of an unidentified individual is often compared to the age listed in a missing persons report and may be used as a basis to either include or exclude the individual from further consideration. Unless substantial differences in age exist, age should not be the sole basis for exclusion.

This document was revised, prepared, and finalized as a standard by the Anthropology Consensus Body of the AAFS Standards Board. The draft of this standard was developed by the Anthropology Subcommittee of the Organization of Scientific Area Committees (OSAC) for Forensic Science.

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- the term 'shall' indicates that a provision is mandatory, and can be audited for compliance
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All hyperlinks and web addresses shown in this document are current as of the publication date of this standard.

Keywords: *Forensic anthropology, age estimation, biological profile, personal identification.*

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Standard for Age Estimation in Forensic Anthropology

1 Scope

Age is one of several biological parameters that can be estimated from skeletal material or ~~radiographic images.~~medical imaging. This standard provides general procedures for the estimation of age from skeletal material or ~~radiographic images. This standard includes the estimation of age at death from skeletal remains and can also be applied to skeletal development from living individuals.~~ medical imaging.

Specific methods and techniques are not included in the standard.

2 Normative References

There are no normative reference documents. ~~Annex A, Bibliography, contains informative references.~~

3 Terms and Definitions

3.1
accuracy
Refers to a combination of trueness and precision.

~~3.1~~**3.2**
age estimation
The estimation of chronological age from osseous, dental, and/or cartilaginous material, reported as an interval.

~~**3.2**~~
~~**age mimicry**~~
~~When an applied age estimate approximates (i.e., "mimics") the age distribution of the reference sample upon which the method was based.~~

3.3
age mimicry
A phenomenon that occurs when means and confidence intervals for particular features/phases are calculated directly from the ages of individuals with those features in the reference sample, resulting in a method that produces results more influenced by the composition of the reference sample than the true age distribution of the features in the population.

~~3.3~~**3.4**
biological profile
The description of an individual's estimated sex, ancestry, age, and living stature derived from an anthropological (skeletal) analysis.

~~3.4~~**3.5**
chronological age
The age of an individual in years, months, and/or days, calculated as the difference between the individual's date of birth and a specific later date.

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~~3.5~~3.6

dental development

Growth and maturation of the dentition, including enamel mineralization, crown, and root formation.

~~3.6~~3.7

dental eruption

The process of ~~emergence of the primary (deciduous) or secondary (permanent) teeth~~tooth migration from its initial position in its bony crypt through the alveolar bone~~.~~, the gingival tissue, and toward the occlusal plane.

NOTE For the purpose of forensic anthropology, most methods consider only eruption through the alveolar bone.

~~3.7~~3.8

secular change

Change in phenotype (e.g., stature) in a population over time.

3.9

skeleton/skeletal

Osseous, cartilaginous, and/or dental tissues.

4 Requirements

4.1 General

Skeletal ~~remains~~elements and imaging thereof shall be analyzed in a reliable and systematic manner to estimate age. Methods applied to estimate age shall be appropriate for the skeletal elements available~~.~~ and their general developmental stage. All methods used shall be documented to allow verification and replication of the work performed.

Age estimation shall be made independently of suspected or presumptive identification to minimize cognitive bias.

Extensive knowledge of skeletal anatomy, including the range of normal human variation and experience with various age-estimation methods, is required~~.~~ to correctly apply methods and interpret results.

Age estimation from skeletal remains should be conducted even if DNA or other analyses will be performed.

Age estimation shall follow methods published in peer-reviewed sources ~~and shall be reported as an age interval. Existing reference standards for a method shall be used.~~ .

If one or more ~~of the~~ bones ~~or features needed~~required to apply a specific method are absent, the method shall not be used. If a method utilizes multiple skeletal elements/features and enough are present to sufficiently apply a method, it may be used at the discretion of the practitioner. The quality of available skeletal material shall be considered when selecting a method.

All test results and observations shall be documented and described, including those that are inconsistent with the final age estimate.

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Forensic anthropologists shall comply with all legal responsibilities needed to complete their analyses, which may include state and local laws regarding consent, obtaining medical records, and storing personal data.

4.2 Procedure

4.2.1 General

Choice of age-estimation methods shall be dictated by the skeletal elements available, their condition/degree of preservation, and the ~~general~~ age ~~of~~group to which the individual belongs (i.e., subadult vs. adult remains).

Relevant, published methods shall be followed, and validated methods should be given preference. When multiple methods are available, the method(s) with the greatest accuracy and most appropriate reference sample(s) (in terms of sample size, time period, genetic, cultural, and/or environmental similarity) shall be given greater consideration when synthesizing an age estimate. ~~Age estimates from multiple~~If a sample representative of the unknown skeleton is not used or if the appropriate reference is not known, the examiner shall address the resulting uncertainty in developing an estimated age using methods ~~shall not be averaged~~developed for this purpose.

~~Published methods shall be followed. Whenever possible, methods developed on a population representative of the unknown skeleton shall be used.~~

Means or other measures of central tendency from multiple methods shall not be averaged.

4.2.2 Fetal Age Estimation

Fetal age is reported in gestational weeks. Age estimation shall be based on long bone lengths, individual bone development, and/or developing dentition.

4.2.3 Infant and Child Age Estimation

Infant and child age estimation shall be based on dental and skeletal indicators including dental development, dental eruption, ~~and/or osseous development (e.g., primary centers of ossification~~ diaphyseal dimensions, and appearance and maturation of ~~other skeletal elements). Age estimates based on dental development are the most accurate and shall be given greater consideration~~ossification centers.

4.2.4 Adolescent/Young Adult Age Estimation

Adolescent and young adult age estimation shall be based on dental development, dental eruption, epiphyseal formation, and/or epiphyseal union.

4.2.5 Adult Age Estimation

Adult age estimation shall be based on skeletal maturation, degeneration, and/or microscopic features.

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4.2.6 Considerations and Adjustments

Both sex-based and population-based variation exists in dental and osteological development. When prioritizing method selection, consider potentially confounding factors, such as socio-economic status, secular change, pathological conditions, trauma, taphonomy, and biomechanical demands on the skeleton. Age predilection of some pathological conditions may offer insights into age estimations. The age estimate shall consider intrinsic or extrinsic variables for which there is evidence that may impact age estimation during the anthropological analysis.

~~In theory, radiographic age-estimation protocols can also be used to analyze skeletal development in living individuals. In practice, however, these applications are limited in their utility. Most commonly, age estimation in the living is used to determine whether or not an individual has reached the age of majority (i.e., if the individual has reached legal adulthood). Considering the widespread variation in timing of epiphyseal union or dental development based on sex, population, or factors unique to an individual (e.g., genetics, environmental stress), it is acknowledged that rarely, if ever, could a practitioner say with certainty that an individual near the age of majority is either a minor or an adult. If such estimates are made, the practitioner shall be forthright regarding the associated error and/or uncertainty.~~

~~Age mimicry may represent a complicating factor when estimating age.~~

Choice of statistical model, age mimicry, conditional independence/dependence of features with age, and the heteroscedasticity of age-related data, are complicating factors when comparing the results of validation studies and interpreting the results of age-estimation methods. Individual practitioners cannot directly resolve these issues, but should be aware of their potential impacts.

Methods used to age younger individuals typically result in more narrow intervals than those for older individuals. With increasing chronological age, the variation produced by environmental factors and life history tends to increase.

In theory, age-estimation protocols can also be used to analyze skeletal development in living individuals, typically to address a question of whether an individual has reached the age of majority. In practice however, due to biological variation as well as method error, forensic anthropologists should not estimate age in living individuals to answer any question that involves a point estimate of age.

Documentation and ~~Both sex-based and population-based variation exists in dental and osteological development.~~

4.2.7 Reporting

All raw data, techniques, and interpretation shall be documented. Documentation should take the form of text and/or images and shall be recorded and maintained in accordance with agency or institutional policy. If multiple methods are used, explanation as to how a final minimum age and maximum age were produced, shall be documented. Documentation should allow for an independent examiner to assess how the final estimate was produced.

Specific method(s) used to generate an age estimate shall be reported. An age estimate shall be reported as an interval, per method specification (e.g., 95% confidence/prediction interval~~). A~~, two-

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standard deviation range, posterior probabilities). If a method produces a point estimate, that may be reported ~~as well.~~

~~All techniques used shall be documented to allow verification and replication of results.~~

~~Raw data shall be recorded and maintained.~~

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~~Annex A~~
~~(informative)~~

~~Bibliography~~

~~The literature presenting method development, method validation, and case studies of age estimation in forensic anthropology is extensive. The following bibliography is not intended to be an all-inclusive list or a robust literature review. The goal of the bibliography is to provide one or two examples of publications focused on points addressed in the standard. Additionally, any mention of a particular software tool or vendor as part of this bibliography is purely incidental, and any inclusion does not imply endorsement.~~

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