Roll-Up, Life-Sized Juvenile Age Estimation

Format: In-person or online

Fabric skeleton with color coded epiphyses

Author: Rebecca J. Gilmour

Time needed: 15 minutes - 2 hours[1]

Learning Objectives

- Observe various patterns in epiphyseal fusion
- Read ossification and fusion charts in order to estimate the most likely age-range of each individual.
- Think critically about how age at death is estimated from juvenile (subadult) skeletons,
- Identify limitations and challenges of estimating MNI in archaeological or forensic contexts.

Supplies Needed

- Fabric/paper skeleton prints with color coded epiphyses (image attached)
    - Some individuals can be supplemented with other information (e.g., hand x-rays, plastic skeletal casts, see below)
- Blank fabric/paper skeleton print
- Washable colored markers
- Epiphyseal fusion and dental development charts
- Graph paper

Readings

- Kendell, Ashley et al. 2019. Chapter 15: Bioarchaeology and Forensic Anthropology. *Explorations*.
- Organ, Jason and Jessica Byram. 2019. Appendix A: Osteology. *Explorations.*

[1] The time required for this activity varies depending on the combination of components observed. The activity can range from 15 minutes (one individual from Part I) to 2 hours (multiple individual observations from Part I, creation of an individual in Part II, and a final discussion).

Introduction

This activity aims to get learners thinking critically about how age at death is estimated from juvenile (subadult) skeletons. It uses skeletal images printed on paper or cloth, and then the metaphyses or epiphyses are colored (to represent ossification/fusing), so that students can evaluate to estimate skeletal age. In Part 1, students estimate the age of a pre-prepared individual. In Part 2, students will apply what they have learned to create their own growth and development templates. Finally, they should present their observations and discuss any limitations and difficulties they encountered.

Steps

Preparation of Materials

This activity requires the instructor to print illustrations of a sub-adult skeleton marked with colored pens to indicate skeletal ossification and fusion. A template for the subadult skeleton is found at the end of this activity guideline and can also be retrieved from rebeccagilmour.ca.

One option is to print the skeletal illustration on fabric. The author (Gilmour) had hers printed life-sized on lightweight cotton twill fabric via spoonflower.com. If washable markers are used on the fabric, the skeleton prints are (theoretically) able to be cleaned and reused. The images can also be printed on paper; if laminated, dry erase markers can make the templates reusable. While it is not necessary to print the skeleton diagram as life-sized, doing so will make the exercise feel more authentic.

For Part I of the exercise, the instructor must decide what approximate ages they would like each skeleton to depict. Using skeletal fusion charts and information (such as provided by Scheuer and Black 2000), color in the metaphysis or epiphysis to indicate if the element is not yet ossified, unfused, fusing, or fused. Suggested color codes are:

Purple = Not Yet Ossified
Green = Unfused
Yellow = Fusing
Red = Fused

Each skeletal diagram should be supplemented using freely-available dental and hand radiographs from the Burlington Growth Study; available online at: https://www.aaoflegacycollection.org/aaof_collection.html?id=UTBurlington.

Student will also need to be provided and shown how to use epiphyseal fusion and dental development charts, such as those from White and Folkens (2005) and Scheuer and Black (2000).

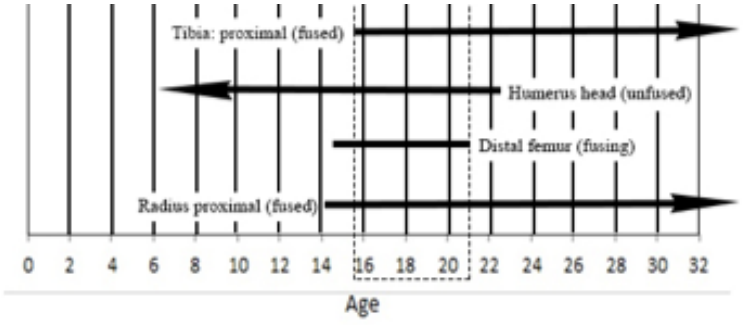
Part 1: Estimate the Age of Pre-Prepared Juveniles

- Distribute color-coded skeletal illustrations (and supplementary radiographs) to students or small groups of students.
- Have students work in groups to observe each epiphysis and element. In consultation with epiphyseal ossification and fusion charts and dental development diagrams, ask students to record each attribute, the state of fusion, and their age estimation for that specific element, epiphysis, or observation using a table (see example below).

Example of a table to record observations alongside their associated age interpretations.

Epiphysis	State of Fusion	Age Interpretation (years)
Proximal humerus (head)	Unfused	<20
Distal radius	Fusing	14-20
Proximal Ulna	Fused	>12

- Next, ask students to visualize the overall age-estimation by plotting each age range for each growth and development observation on graph paper (see figure below).
- Students should label the x-axis with age and plot each age range for each point of fusion/development along the y-axis. Students should be reminded to always report age ranges in osteological assessments, as there is some error associated with these methods (some individuals will fuse earlier or later than others)



Plotted age-estimations with area of greatest age overlap indicated with a dotted line. See White and Folkens (2005: 373, Fig. 19.6) for similar fusion charts.

- Using the chart they have created, students should look for the region of greatest age overlap. The area of greatest overlap is indicated by dotted lines in the figure above.
- Once students have estimated the age of the individual at one station, they should cycle through stations until they have estimated all the ages of all the stations the instructor created.

Part 2: Create Your Own Sub-Adult

- In this stage of the exercise, students will apply what they have learned to create their own growth and development templates (these may be used by the instructor in future iterations of the course and activity).
- Provide students with a completely blank sub-adult poster/canvas. Secretly assign them an age at death for their specific individual. You may choose to put ages on slips of paper and have students draw these at random.
- Students should refer to the charts in White and Folkens (2005) and Scheuer and Black (2000) to color in the epiphyses that would be not ossified yet, unfused, fusing, or fused. They should adhere to the same color scheme as the instructor:

  Purple = Not Ossified Yet!
  Green = Unfused
  Yellow = Fusing
  Red = Fused

- Have students illustrate and indicate an appropriate pattern of dental development and eruption. Be able to discuss what you would expect to observe on their individual's dental radiograph.
- Once students have completed their growth and development schematics, have them trade their work with a neighboring group. Time the groups to see who can estimate the age fastest while obtaining the most accurate age estimation. At the instructor's discretion, the fastest and most accurate group could win a prize.

Conclusion

- At the end of each exercise, have students briefly present their observations.
- Check with the students to talk about the limitations and difficulties they encountered. Be sure to discuss how this stylized activity may differ from actual analysis of archaeological human bone.
- Discuss limitations to age-estimation techniques as they relate to preservation and collection/curation complications. For example, you may ask the class: "What if none (or only some) of the epiphyses were collected during excavation? How would the anthropologist know they were missing (as opposed to not ossified)? Could the anthropologist still estimate the age of the individual?"

Adapting for Online Learning

1 Not adaptable 2 Possible to adapt **3 Easy to adapt**

This activity can easily be adapted for online use by providing students with a small library of digitized skeleton diagrams (supplemented as needed using images from the Burlington Growth

Study). The instructor may wish to print, color, and scan images to be sent to students. Students can independently estimate skeletal age, and using LMS discussion forums or Google Docs, critically discuss their estimated ages with each other. Students can also generate their own growth and development diagrams to share and test each other in these forums.

For Further Exploration

Various craniofacial growth studies curated online by the American Association of Orthodontists Foundation (AAOF) https://www.aaoflegacycollection.org/aaof_home.html

The University of Toronto Burlington Growth Study (includes craniofacial and hand/wrist images) https://www.aaoflegacycollection.org/aaof_collection.html?id=UTBurlington

J-Skel The Digital Age Estimator of Subadult Skeletons http://j-skel.matrix.msu.edu/

References

The University of Toronto Burlington Growth Study. https://www.aaoflegacycollection.org/aaof_collection.html?id=UTBurlington

Kendell, Ashley, Alex Perrone, and Colleen Milligan 2019. “Chapter 15: Bioarchaeology and Forensic Anthropology.” In Explorations: An Open Invitation to Biological Anthropology, edited by Beth Shook, Katie Nelson, Kelsie Aguilera, and Lara Braff. Arlington, VA: American Anthropological Association. http://explorations.americananthro.org/

Life Size Printout, Juvenile, Modern Homo sapiens. eSkeletons.org http://eskeletons.org/sites/eskeletons.org/files/files/resources/000646791.pdf

Organ, Jason and Jessica Byram. 2019. “Appendix A: Osteology.” In *Explorations: An Open Invitation to Biological Anthropology*, edited by Beth Shook, Katie Nelson, Kelsie Aguilera, and Lara Braff. Arlington, VA: American Anthropological Association. http://explorations.americananthro.org/

Scheuer, Louise and Sue Black. 2000. *Developmental Juvenile Osteology.* San Diego: Elsevier.

White, Tim D. and Pieter A. Folkens. 2005. *The Human Bone Manual.* San Diego: Elsevier Academic Press.

Image Attributions

Fabric skeleton with color coded epiphyses photo by Rebecca Gilmour original toExplorations Lab and Activities Manual is under a CC BY-NC 4.0 License.

Plotted age-estimations with area of greatest age overlap indicated with dotted line by Rebecca Gilmour original to Explorations Lab and Activities Manual is under a CC BY-NC 4.0 License.

Life Size Printout, Juvenile, Modern Homo sapiens outline drawn by by R.A. Menegaz, eskeletons.org has been modified (images merged, lines redrawn) by Rebecca Gilmour for Explorations Lab and Activities Manual and is used under a CC BY-NC-SA license.

Roll-Up, Life-Sized Juvenile Age Estimation Worksheet

Part 1: Estimate the Age of Pre-Prepared Juveniles

1. On each skeleton, a series of epiphyses have been color coded according to their degree of fusion:

   Purple = Not Ossified Yet!
   Green = Unfused
   Yellow = Fusing
   Red = Fused

2. Observe each epiphysis and consult the epiphyseal ossification and fusion charts and dental development diagrams in White and Folkens (2005) and Scheuer and Black (2000). Then create a table to help you record your observations and age ranges. An example table is provided below. Please create yours at the top of a sheet of graph paper.

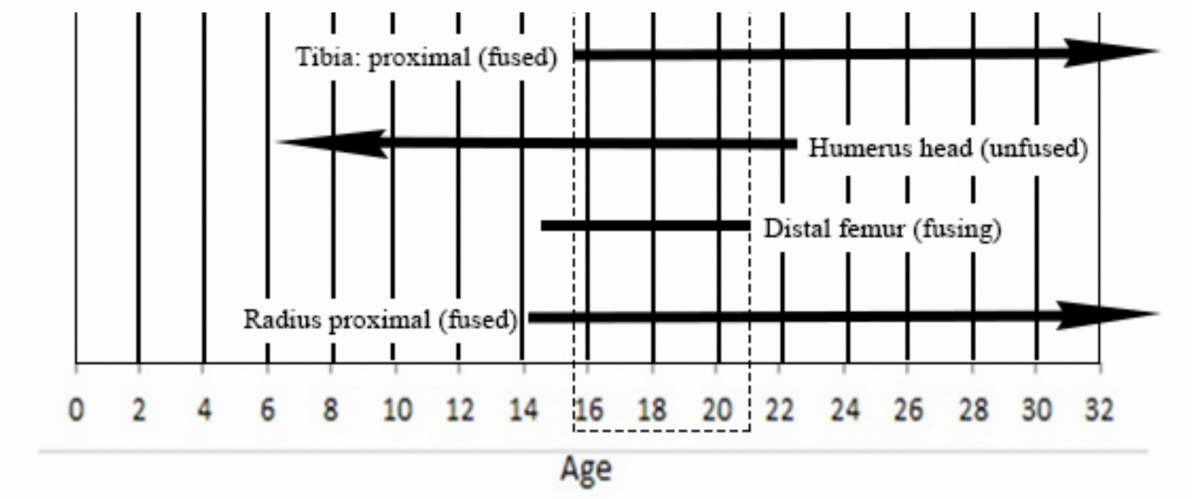
Example of a table to record observations alongside their associated age interpretations.

Epiphysis	State of Fusion	Age Interpretation (years)
Proximal humerus (head)	Unfused	<20
Distal radius	Fusing	14-20
Proximal Ulna	Fused	>12

3. Observe the pattern of dental development and eruption for each individual. Consult dental development/eruption charts in White and Folkens (2005). Which pattern of development and eruption does your individual best match? Record the age range in your table (on the graph paper).

4. Visualize your age-estimations by plotting the age range for each element's fusion and the dental development pattern on a chart using the graph paper, similar to that of the figure below. Be sure to label your x-axis with age and plot your age range interpretations for each observation along the y-axis.

5. Find the area of the greatest age overlap in your chart. This range is your individual's best estimated age at death. The area of greatest overlap is indicated by dotted lines in the figure below. Remember to always report age ranges in osteological assessments, as there is some error associated with these methods (some individuals will fuse earlier or later than others). What is your estimated age at death range?



Plotted age-estimations with area of greatest age overlap indicated with a dotted line. See White and Folkens (2005: 373, Fig 19.6) for similar fusion charts.

Part II: Create Your Own Sub-Adult

1. On a blank sub-adult poster, use the colored markers to create a fusion pattern consistent with the osteological age range your instructor secretly assigned you.

   Age Assigned By Instructor: _____

   Indicate your fusion/ossification patterns using the following colors:

   Purple = Not Ossified Yet!
   Green = Unfused
   Yellow = Fusing
   Red = Fused

2. Illustrate and indicate an appropriate pattern of dental development and eruption. Be able to discuss what you would expect to observe on your individual's dental radiograph.

3. Trade your sub-adult poster with a neighboring student/group. Test yourselves: see who can estimate the age the fastest, while remaining accurate!

Conclusion: Present your Observations and Discuss

1. How old was your individual? Tell your classmates why you estimated the age range as you did.

2. What limitations and difficulties did you encounter?

3. How might this stylized activity differ from actual analysis of archaeological human bone? Discuss limitations to age-estimation techniques as they relate to preservation and collection/curation complications.

Juvenile Skeleton