Small but significant: Age-at-death estimation from the developing epiphyses and metaphyses of the six long bones

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INTRODUCTION

No studies thus far have examined the utility of the epiphyses and metaphyses of the long bones in death for the purposes of age estimation, with exception of those at the knee [1]. This study explores and models the relationship between these bone portions and age, for all six of the long bones.

MATERIALS & METHODS

Age estimation formulae were calculated using measurement data from 148 individuals (56 females, 92 males) of known age from two historic skeletal collections in Portugal and England (Figure 1), ranging from birth to 12.99 years. The years of death range from 1805–1975 for the Portuguese (Lisbon) individuals, and 1759–1852 for the English (Spitalfields) individuals [2].

ANCOVA was used to evaluate differences between Portuguese and English sub-samples. Formulae were calculated via least square linear regression and classical calibration for each measurement—for the sexes separately and combined.

Accuracy and precision of the models is measured with mean residuals, mean absolute residuals, and 95% confidence intervals constructed from the mean standard errors for individual predictions (MSEs) multiplied by 2. The estimation equations take the form:

\[
\text{Age} = \frac{\text{bone dimension} - \text{intercept}}{\text{slope}} \pm \text{MSE.}
\]

RESULTS

ANCOVA results revealed relatively little or no effects of collection or sex. Based on regression trend lines, regression formulae include the full sample for the epiphyses, while split at age 2 for the metaphyses.

The models show no mean difference between estimated and chronological age (MRs equal 0). The minimum percentage of individuals whose chronological age is within the 95% confidence interval across all models is 89.5%.

Table 1. Best performing models (equations and descriptive data)

<table>
<thead>
<tr>
<th>Sex</th>
<th>Epiphyses</th>
<th>Metaphyses &lt; age 2</th>
<th>Metaphyses ≥ age 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>Tibia proximal</td>
<td>Age t width = -16.03</td>
<td>Age t width = -10.54</td>
</tr>
<tr>
<td></td>
<td>3.43</td>
<td>± 1.58</td>
<td>± 0.20</td>
</tr>
<tr>
<td></td>
<td>Tibia distal</td>
<td>Age t width = 15.50</td>
<td>Age t width = 8.97</td>
</tr>
<tr>
<td></td>
<td>2.32</td>
<td>± 0.56</td>
<td>± 0.60</td>
</tr>
<tr>
<td>Males</td>
<td>Tibia proximal</td>
<td>Age t width = -12.11</td>
<td>Age t width = -10.26</td>
</tr>
<tr>
<td></td>
<td>4.25</td>
<td>± 0.83</td>
<td>± 0.28</td>
</tr>
<tr>
<td></td>
<td>Tibia distal</td>
<td>Age t width = 9.42</td>
<td>Age t width = 5.88</td>
</tr>
<tr>
<td></td>
<td>2.16</td>
<td>± 0.29</td>
<td>± 0.52</td>
</tr>
</tbody>
</table>

Figure 1. Composition of the study sample

DISCUSSION & CONCLUSION

The epiphyses have generally larger MSEs than the diaphyses [2] of the same long bone, but in some cases the difference is comparable or relatively small (Figure 2).

Compared to diaphyseal models [2], MSEs are also mostly larger for the metaphyses in individuals younger than and older than 2 years, though sometimes marginally (Figures 3 and 4). Some metaphyses perform better than the diaphysis in individuals younger than age 2 (e.g., the distal tibia in Figure 3).

Somewhat comparable models of teeth [3] indicate larger MSEs for the long bone epiphyses, though values are better than or similar to that of the third molar.

Although the epiphyses and metaphyses generally perform poorer compared to the diaphyses and the teeth, they can be useful as additional resources for age estimation, particularly in cases of fragmented remains.

REFERENCES

