# Identifying Pre-Incineration State from Heat-Induced Fracture and Warping Patterns Found on Human Remains in a Hungarian Bronze Age Cemetery

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## Introduction

The purpose of this research is to examine the possible internal social structures of a Bronze Age population in the Körös region of Eastern Hungary by testing whether or not trends in the distribution of macroscopic heat-induced features exist across the cemetery site of Békés 103. Fragments from fourteen cremation urns were assessed for the presence of diagnostic fracture and warping patterns according to their anatomical region. Their relative frequencies were then compared among human burials and among urn layers.

*Sample:* The Bronze Age Körös Off-Tell Archaeology (BAKOTA) team has excavated 64 cremation burials and five inhumations from the cemetery since 2011. This research will focus on 14 cremated human burials of varying ages and sexes from different areas of Békés 103 to facilitate an analysis fully spanning the cemetery. Remains from each human burial (HB) are divided by the urn layer from which they were excavated, and a random twenty percent sample was taken from each layer for evaluation.

*Heat-induced features:* The withdrawal of muscle fibers and tissues from the distal ends of long bones and towards the axial bodies of fleshed individuals results in the formation of curved transverse fractures (Symes et al. 2015). Prominent longitudinal fractures running along osteon canals in addition to superficial patina cracks found around epiphyseal ends and on the flat planes of postcranial bones also frequently appear on cremains (Buikstra & Swegle 1989). The similar corruption of cranial flesh due to burning produces delamination on surfaces thinly covered by skin in addition to curved regression fractures on meatier portions of the anterior face (Pope & Smith 2004). Warping, particularly of diaphyses, is another consequence of heat exposure; the combustion temperature, degree of collagen preservation, and the amount of bone recrystallization are suggested causes. (Cunha, Gonçalves, & Thompson, 2011).

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## Materials and Methods

The frequency of fractures and warping patterns was quantified for fourteen human burials: 10, 11, 12, 13, 21, 28, 46, 47, 48, 49, 50, 51, 53, and 54. A random twenty percent sample was taken from each layer per human burial by evenly scattering fragments across a 20 x 25cm grid and subsequently selecting a single 5 x 5 cm square from each row for evaluation. Cranial and postcranial heat-induced fracture patterns are generally distinct from one another. Therefore, samples from each burial were organized according to these two anatomical regions (Pope & Smith 2004). Within the broader cranial and postcranial categories, only diagnostic fragments (those specifically identified or those identified as either cranial or postcranial) were considered. Macroscopic fractures were assessed for a particular type's presence or for its absence based on the fragment's anatomical location using a hand lens. Longitudinal, straight transverse, curved transverse, patina, and non-directional fractures were considered for postcranial elements (Symes et al. 2015). Non-directional fractures were evaluated for postcranial elements that could not be conclusively attributed by the authors to a bone possessing directionality (i.e. evidence of osteon canals or hollow space for marrow in long bone shafts). Delamination, linear, and curved transverse fractures were considered for cranial elements (Symes et al. 2015). Warping was evaluated for both postcrania and crania. Every fragment was assigned an ID indicating the human burial to which it belongs and its order within the burial according to an arbitrary numbering system. These data were collected in conjunction with information detailing the remains' urn layer and HB/lot number.

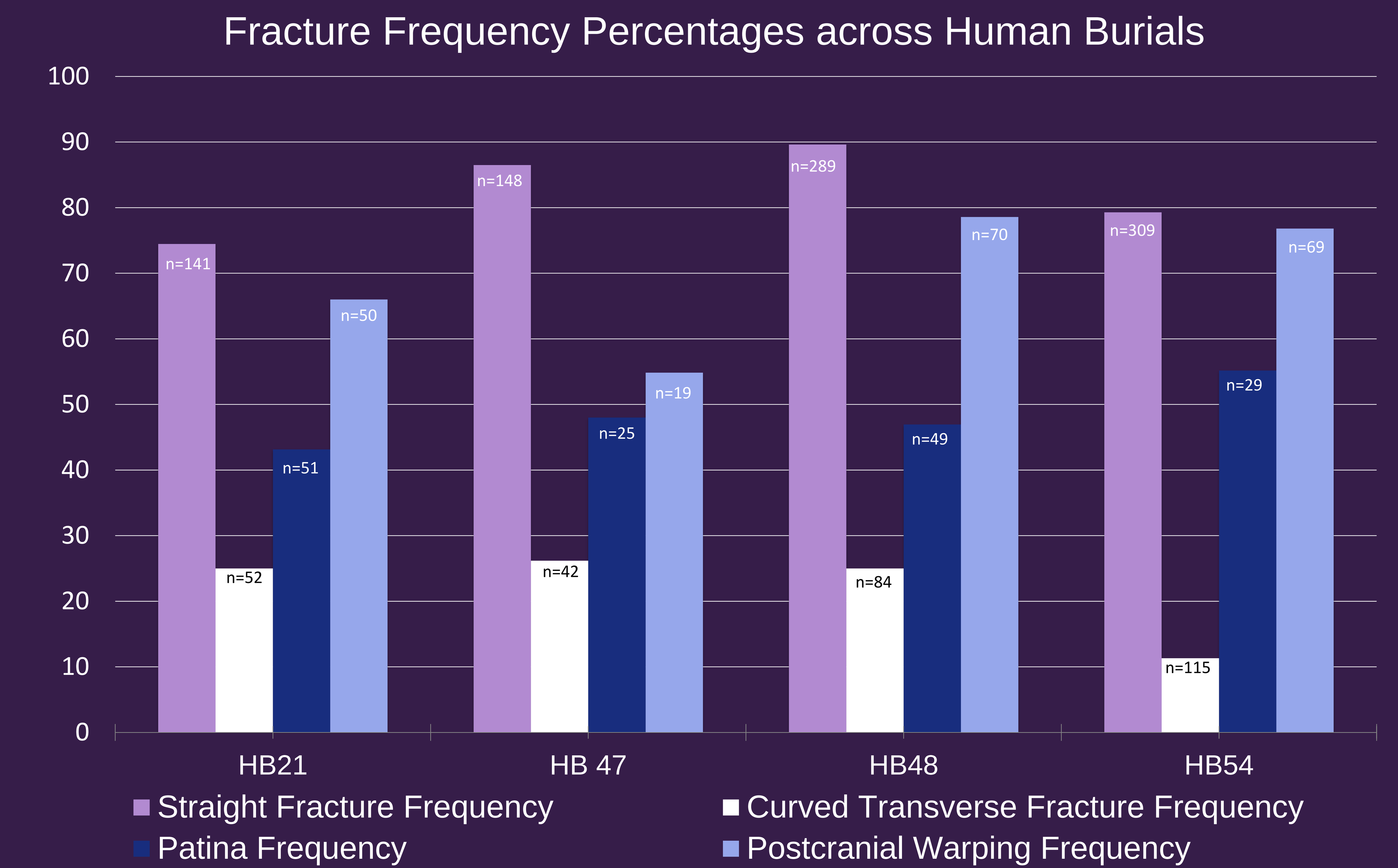


Figure 1: Comparison bar graph of postcranial fracture type frequencies across qualifying human burials.


Picture 1: Example of patina from burial 48


Picture 2: Example of non-directional fractures from burial 28


Picture 3: Example of curved transverse fractures from burial 46


Picture 4: Example of postcranial warping from burial 28

## Fracture Frequency Raw Data

| | CRANIAL FRACTURES | | | | | | | | POSTCRANIAL FRACTURES | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Delamination | | Linear Fx | | Curved Fx | | Warping | | Longitudinal | | Non-Directional | | Straight Transverse | | Curved Transverse | | Patina | | Warping | |
| | + | n | + | n | + | n | + | n | + | n | + | n | + | n | + | n | + | n | + | n |
| HB21 | 9 | 14 | 23 | 0 | 13 | 10 | 7 | 2 | 47 | 7 | 30 | 6 | 28 | 23 | 13 | 39 | 22 | 29 | 33 | 17 |
| HB46 | 4 | 1 | 11 | 0 | 1 | 10 | 2 | 3 | 18 | 2 | 69 | 4 | 11 | 4 | 8 | 6 | 11 | 2 | 13 | 6 |
| HB 47 | 11 | 3 | 21 | 1 | 3 | 19 | 8 | 1 | 44 | 0 | 54 | 6 | 30 | 14 | 11 | 31 | 12 | 13 | 17 | 14 |
| HB48 | 15 | 10 | 43 | 2 | 8 | 31 | 8 | 7 | 93 | 4 | 93 | 8 | 73 | 18 | 21 | 63 | 23 | 26 | 55 | 15 |
| HB49 | 9 | 8 | 20 | 3 | - | - | - | - | 18 | 3 | 67 | 1 | 19 | 2 | 6 | 15 | - | - | 4 | 7 |
| HB50 | 9 | 3 | 9 | 3 | - | - | - | - | 12 | 1 | 41 | 1 | 8 | 5 | 3 | 10 | - | - | 5 | 3 |
| HB51 | 9 | 3 | 13 | 0 | 3 | 10 | 4 | 1 | 8 | 1 | 19 | 2 | 6 | 3 | 4 | 4 | - | - | - | - |
| HB53 | 3 | 1 | 3 | 1 | - | - | s | - | 6 | 0 | 23 | 3 | 6 | 0 | 4 | 3 | - | - | - | - |
| HB54 | 16 | 14 | 52 | 3 | 4 | 48 | 3 | 3 | 114 | 6 | 67 | 6 | 64 | 52 | 13 | 102 | 16 | 13 | 53 | 16 |

Figure 2: Raw data table of cranial and postcranial features across nine human burials–- burials for which sample sizes were too small or expected frequencies were <5 were not included in final analyses. "+" indicates presence, and "n" indicates absence.

## Results

Of the fourteen original human burials, nine human burials were compared, and the urn layers from ten human burials were compared. Given the small sample size available for cranial elements, statistical analyses utilizing chi square focused solely on postcranial elements in the examination of human burials. Additionally, straight fractures (longitudinal, non-directional, and straight transverse) were assessed together because they are similar to one another and because individually they yielded too small a sample size. Four human burials had sufficient samples to use the chi-square statistic. Results indicated that significant differences exist among burials in regards to the distribution of straight fractures ($p=6x10^{-6}$) and curved transverse fractures ($p=0.035$) only. As indicated by the corresponding graph, a relatively low percentage of both straight fractures and curved transverse fractures are found in human burial 21, and a relatively low percentage of curved transverse fractures are found in human burial 54.

## Discussion and Conclusion

This study quantified fracture and warping distributions across fourteen human burials and narrowed its focus to four human burials in particular for chi square analyses. Only two fracture types (straight and curved transverse) varied significantly across human burials, and in regards to these two fracture types, human burials 21 and 54 exhibit relatively low frequencies.

Investigations into the demographics of human burials 21 and 54 indicate that the former is an adult female and the latter is an adult male (Paja et al., 2016). Given how similar these two individuals are to the rest of the cemetery's members, a demographic cause is unlikely. One possibility is that the individuals in human burials 21 and 54 possessed less flesh at the time of cremation than did individuals in the other burials; the manifestation of macroscopic heat-induced features is often attributed to the burning of flesh (Gonçalves and Thompson, 2011). Another potential explanation involves the temperature of the cremation fire. A lower overall temperature or less exposure to intense heat may result in fewer fractures (Chapman, 2015). The low percentages of calcined bone, or bone that was subject to intense heat, among the postcranial fragments in human burials 21 and 54 (35% and 14%, respectively) support this conclusion (Cruz et al., 2017). If the trends discussed above are indeed the product of differential flesh compositions or heat exposures, these findings raise questions asking whether or not additional burials throughout the cemetery express similar abnormalities and whether or not these abnormalities are the result of deliberate or naturally-occurring processes. For example, lower temperatures may have resulted from purposeful preparations of the fire or from natural temperature fluctuations that occur when fire is exposed to the open air. A relative lack of flesh could be the consequence of defleshing the body or letting the body decay some prior to cremation; alternatively, the individuals may have merely possessed less muscle mass at their time of death than others in the cemetery.

## References

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