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Cranial Thickness in American Females and Males

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ABSTRACT: To date, numerous studies have examined the range of cranial thickness variation in modern humans. The purpose of this investigation is to present a new method that would be easier to replicate, and to examine sex and age variation in cranial thickness in a white sample. The method consists of excising four cranial segments from the frontal and parietal regions. The sample consists of 165 specimens collected at autopsy and 15 calvarial specimens.

An increase in cranial thickness with age was observed. The results suggest that cranial thickness is not sexually dimorphic outside the onset of *hyperostosis frontalis interna* (HFI).

KEYWORDS: forensic science, cranial thickness, hyperostosis frontalis interna, forensic anthropology

Cranial thickness has been used to investigate differences between ethnic groups, to account for sexual dimorphism, to expound the phylogenetic relationships of *Homo*, and even to infer behavioral differences (e.g., activity levels). Lieberman proposed that exercise and the levels of growth hormone (GH) released during exercise, not genetics, accounted for most of the variation observed among hunter-gatherers, early agriculturalists, and post-industrial *Homo sapiens* (1). Gauld, however, maintained that variance in vault bone thickness is explained by body size variation (2).

Todd (3) and Getz (4) concluded that cranial thickness increased slightly with age. Adeloye and coworkers observed a rapid increase in cranial thickness in the first two decades and a gradual increase in the third-to-seventh decade of life (5). They also observed that in certain age groups females had significantly thicker cranial bones, although the sex differences were quite variable and dependent upon cranial location (5). The higher incidence of *hyperostosis frontalis interna* (HFI) or marked thickening of the endocranial surface of the frontal bone, among post-menopausal females could explain this increase in thickness in older females (6,7). However, there are almost as many studies that contradict these findings (8–11), studies which found no significant difference in cranial thickness with increased age. Similarly, investigations of sexual dimorphism also yielded inconclusive results (12–15). This inconsistency could be a product of both small sample size and different methodologies used.

The purpose of this investigation is twofold: 1) to introduce a simple, easy to replicate method; and 2) to examine sex and age variation in a white sample.

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Materials and Methods

Sample

The sample was 165 autopsied specimens collected by William F. McCormick, M.D., Deputy Chief Medical Examiner, State of Tennessee, and 15 specimens from the William M. Bass Donated Collection curated at the University of Tennessee, Knoxville (Table 1). The sample consists of 58 females and 122 males. Of these, 144 consist of cranial sections collected at autopsy, and 36 consist of autopsied calvaria. The criteria for inclusion were known age, sex, and race. Manner of death was either by accident, suicide, homicide, or natural causes. *Hyperostosis frontalis interna* was diagnosed as an obvious overgrowth of compact (cortical) bone on the inner table that is generally quite focal and localized to the frontal region but occasionally involves the parietal bones without stigmata of Paget's disease.

Measurements

The general locations of the parietal and frontal eminences were selected for thickness measurements because they are considered to be least affected by structural variations such as ectocranial muscle attachment sites and sinuses (16). Four cranial sections were excised at autopsy from the frontal and parietals (Fig. 1). The bilateral site of excision on the parietal bones is four centimeters postero-laterally from bregma, and four centimeters antero-laterally from bregma on the frontal bone. Cranial sections were removed with a Stryker saw. Measurements on the calvaria were taken at the sites of excision defined above, yielding four thickness dimensions per specimen: right and left parietal and right and left frontal (lp, rp, lf, rf) (refer to Fig. 1). The measurements were taken with Mitutoyo dial calipers to the nearest tenth of a millimeter.

Statistics

Standard summary statistics of the four thickness variables and age were calculated, including means, standard deviations, and intercorrelations. A two-sample t-test was also conducted to determine whether significant differences in group means between females and males were present. An approximate two-sample t-test was obtained for the variables rp, lf, and rf due to unequal

TABLE 1—*Summary of sample (N 4 180).**

	Calvaria	Sections	Total
Females	7	51	58
Males	29	93	122

*Samples were obtained from the Regional Forensic Center, Johnson City, TN (N 4 165), and the Donated Collection, University of Tennessee, Knoxville, TN (N 4 15).

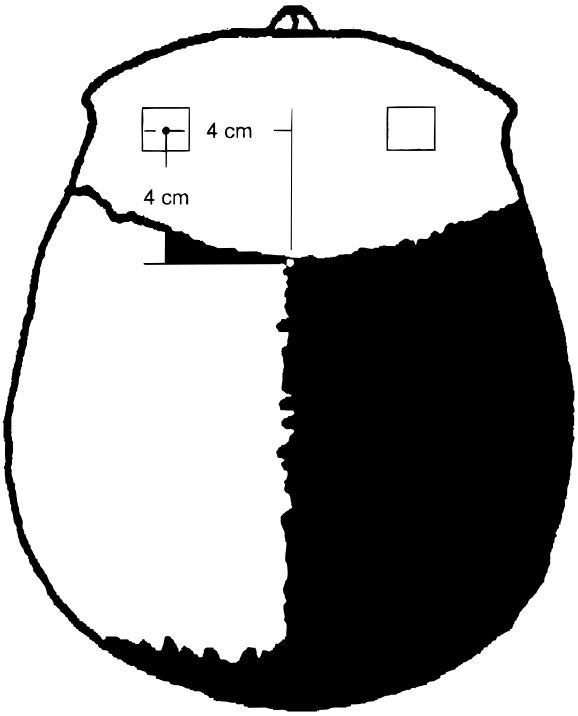


TABLE 3—*Two-sample t-test for sex differences in cranial thickness (F-M).*

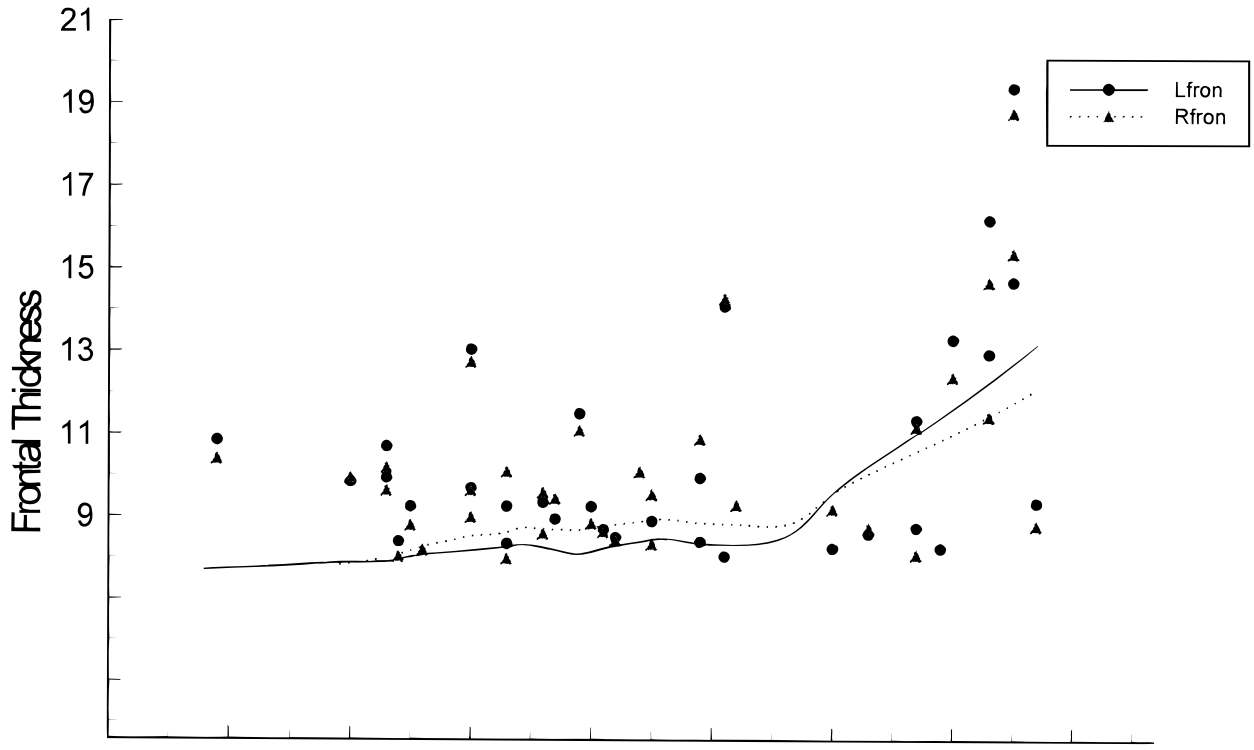
Variable	Variances	T	DF	Prob|T|
LP	equal	2.562	178.0	0.012
RP	unequal	2.617	90.7	0.010
LF	unequal	3.053	79.1	0.003
RF	unequal	3.455	86.3	0.000

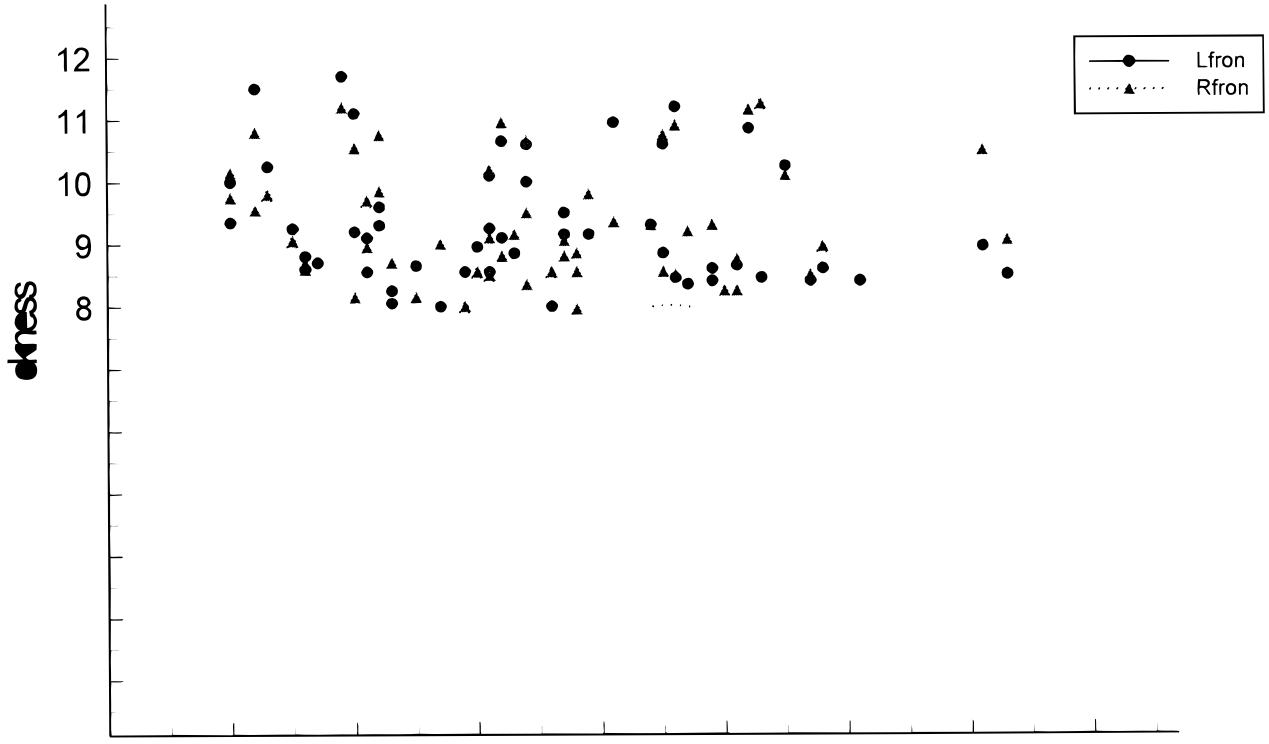
3). The frontal exhibits greater sex differences than the parietal, probably because of the greater incidence of HFI in older females.

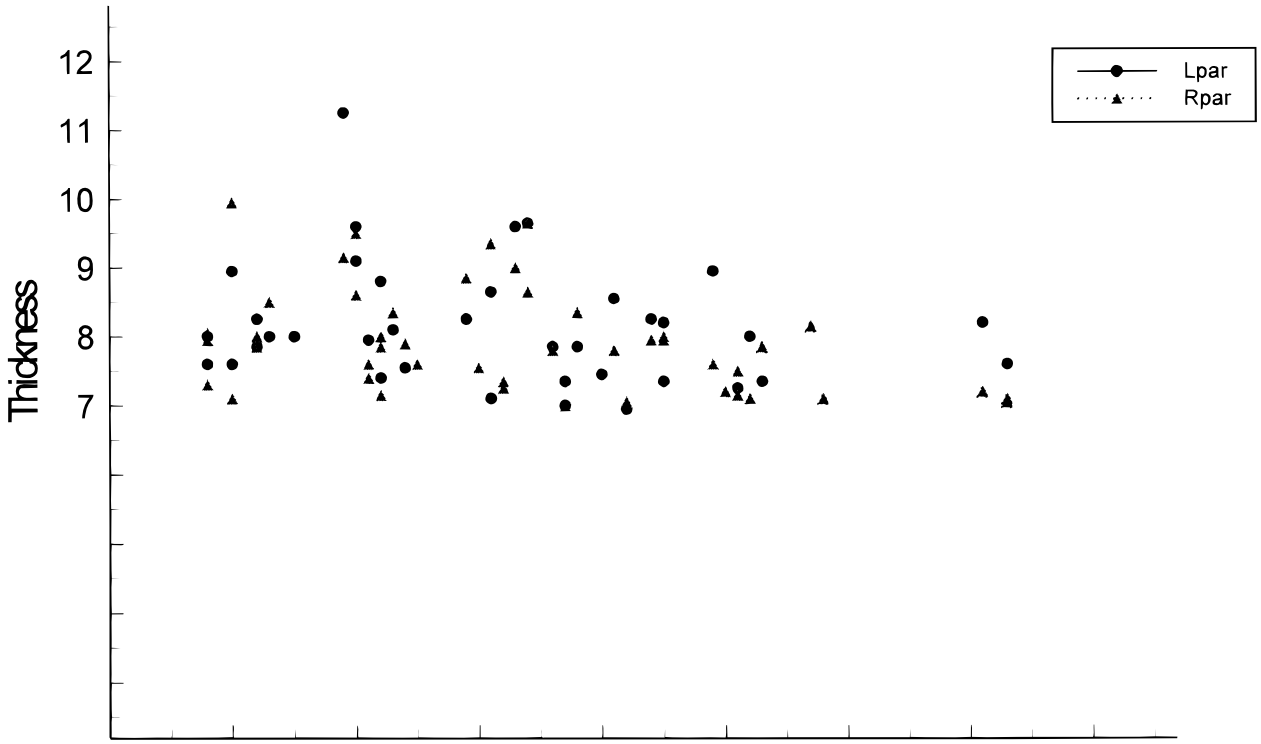
Correlation Analysis

The strengths of the relationships by sex among age, left parietal, right parietal, left frontal, and right frontal were tested using Pearson correlation coefficients. There is evidence of side differences but we are not addressing that at this time. The Pearson correlation coefficients for females and males are presented in Table 4.

The strongest age relationship for females (N 4 58) was observed for the left frontal (r 4 0.4779; $P < 0.0001$). A relationship was also observed between age and right frontal (r 4 0.4464; $P < 0.0004$). The positive correlation between age and left and


21
19
17
15
13
11
9
Frontal Thickness
Lfron
Rfron


12
11
10
9
8
Lfron
Rfron


Thickness
12
11
10
9
8
7
Lpar
Rpar

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