Frontal and Browridge Morphological Covariation in Modern Humans

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Background

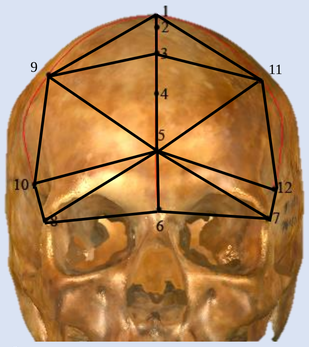
- The evolutionary influence behind the development of the browridge, as well as the source of browridge variation, remain unknown.
- The browridge spatially connects the anterior cranial vault and the superior face, integrating developmentally different regions into one functional unit (1).
- Weidenreich (2) and Moss & Young (3) postulated that the interaction between the neurocranium (specifically the frontal bone) and facial skeleton during development is one of the driving factors behind browridge variation.
- If the browridge does represent a structural bridge between two morphologically distinct regions of the cranium, we would expect a discernable relationship between browridge and frontal morphology.
- Ancestral differences in browridge shape and volume have been observed (4), but their correlation with variation in frontal morphology has yet to be explored.
- The purpose of this research is to investigate any potential morphological covariation between the browridge and frontal bone morphology using geometric morphometric analyses.

Materials and Methods

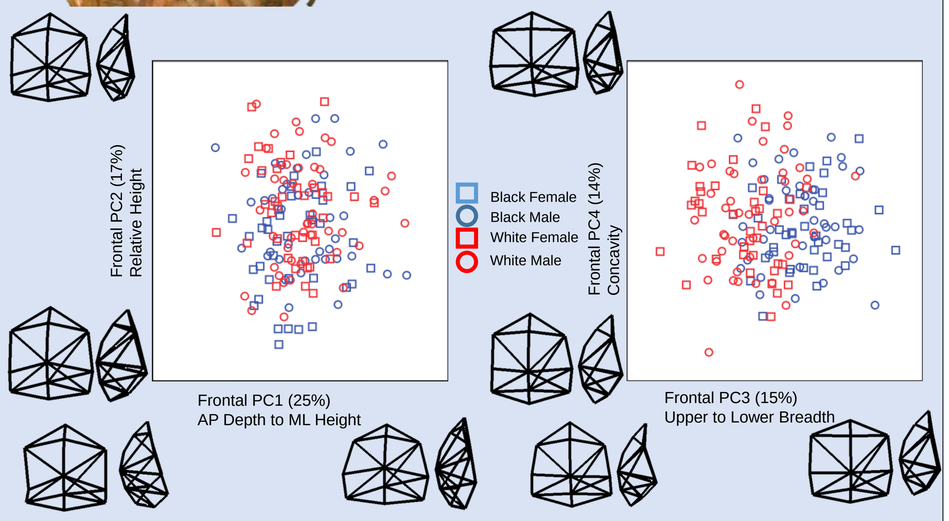
Sample	Ancestry	Males	Females	Demographics
Bass Donated	European-American	22	19	Modern U.S. donated
Kulubnarti	Nubian	25	25	Medieval Nubian cemetery
Terry	African-American	16	14	19th - 20th century U.S.
Terry	European-American	22	19	19th - 20th century U.S.

- HMG collected surface scans of all specimens using a *NextEngine* desktop laser scanner (model 2020i), following the procedures outlined in Garvin and Ruff (4,5).
- Three-dimensional coordinate landmarks were collected in *Geomagic Studio* (6) to capture the overall frontal bone morphology. Semilandmarks were collected along the isolated brow region following Garvin and Ruff (4).
- Procrustes superimposition was performed in *MorphoJ* followed by principal component analysis (PCA).
- PC shape components were interpreted in *MorphoJ* and *Morphologika* (7).
- ANOVA tests were employed to test for differences in sex and ancestry.
- Partial least squares (PLS) regression was run on the Procrustes coordinates in order to assess the overall covariance between brow and frontal morphologies.
- Spearman's rank correlation was run on the first four frontal and browridge PC's to detect any correlations between the individual brow and frontal PC's.
- All statistical analyses were run in *SPSS 22.0* (8) and *MorphoJ*.

Results

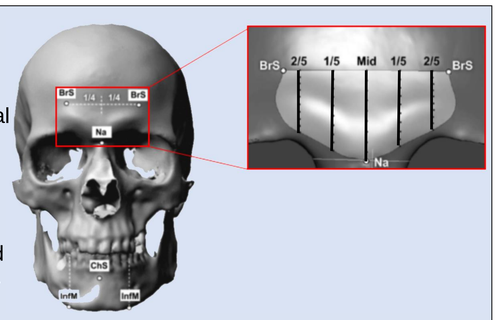


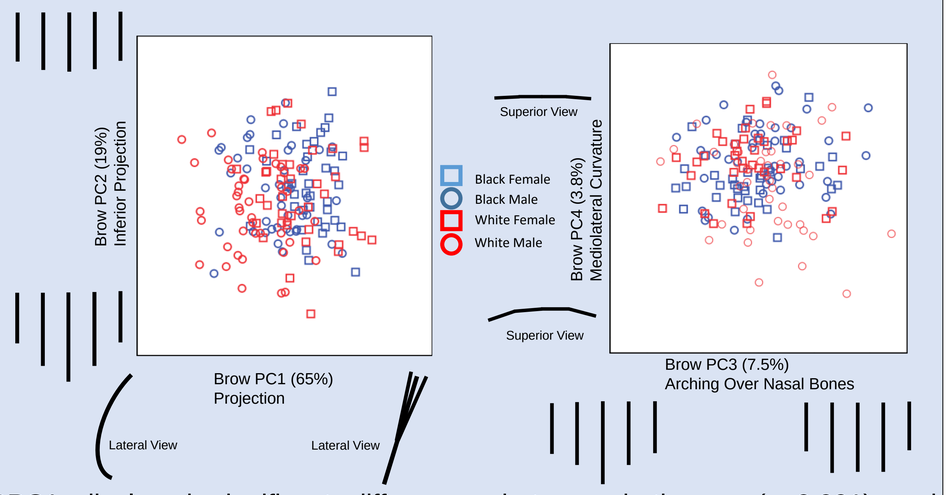
Frontal landmarks: 1) Bregma; 2-5) Four evenly spaced points between glabella and nasion (the area identified as the browridge was avoided); 6) Nasion 7) Left frontomalaretemporale; 8) Right frontomalaretemporale; 9) Right midcoronal; 10) Intersection of the right coronal and sphenofrontal sutures; 11) Left midcoronal; 12) Intersection of left coronal and sphenofrontal sutures



FPC1 displayed sex differences (p=0.044) while ancestral differences were present in FPC2 (p=0.022) and FPC3 (p<0.001).

Browridge isolation following Garvin and Ruff (2012). Any bone projecting anterior to the plane created using the deepest points of the supratoral sulcus at ¼ of the minimum frontal breadth on either side of the midline of the skull and nasion was identified as the browridge. Within this ROI, five equally spaced transects were drawn. Ten evenly spaced semilandmarks were then created along each transect to represent the basic three-dimensional geometry of the ROI.





BPC1 displayed significant differences between both sex (p=0.001) and ancestry (p<0.001).

Partial least squares results

Group	RV Coefficient	p-value
Black Females	0.158	0.062
Black Males	0.156	0.036
White Females	0.181	0.020
White Males	0.133	0.068
All Females	0.098	0.016
All Males	0.094	0.010

		Browridge			
Frontal		BPC1	BPC2	BPC3	BPC4
FPC1	Correlation	-	-	-	-
	(p-value)				
FPC2	Correlation	-	0.26	-	-
	(p-value)		(0.015)		
FPC3	Correlation	-	0.26	-	-
	(p-value)		(0.016)		
FPC4	Correlation	-	0.27	-	-
	(p-value)		(0.011)		

Significant Spearman's correlations (r_s) for pooled males.

		Browridge			
Frontal		BPC 1	BPC2	BPC3	BPC4
FPC1	Correlation	-	-	-	-
	(p-value)				
FPC2	Correlation	-	0.26	-0.25	-
	(p-value)		(0.019)	(0.026)	
FPC3	Correlation	-	0.24	-	-0.34
	(p-value)		(0.038)		(0.002)
FPC4	Correlation	-	-	-	-
	(p-value)				

Significant Spearman's correlations (r_s) for pooled females.

Discussion

- Frontal and browridge morphologies differed between ancestral groups and between sexes.
- The PLS regression with significant, but extremely low RV coefficients indicated a very weak covariation between overall frontal and browridge morphologies. These results suggest that the covariance between these morphologies, is not biologically significant.
- Significant Spearman's correlations only reflected proportional area restrictions, or size-related shape correlations between two structures on the same bone.
- These results were surprising, as one would expect the overall browridge morphology, particularly projection to be significantly correlated with frontal morphology.
- The fact that the two structures showed little covariation beyond proportional area restrictions suggests that the potential effect size of their relationship would be small at best, and much weaker than those related to sex or ancestry differences in each structure separately.

References Cited

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