A MULTI-CAUSAL FUNCTIONAL ANALYSIS OF HOMINID HIP MORPHOLOGY

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Abstract

The skeletal elements of the hip have factored prominently in discussions of the behaviors, life histories, and evolutionary histories of hominids from all time periods. Two particularly intriguing questions are what behavioral and life history differences, if any, existed between Neandertals and modern humans that could explain the demise of the Neandertals, and how rapidly and through what stages did bipedal gait evolve in australopiths? Hip form is functionally constrained by the mechanics of walking and childbirth, and variation between human populations in pelvic width and leg to trunk proportions is related to climate. Therefore, only a multi-causal model that simultaneously considers locomotor, obstetrical, and climatic constraints will be able to explain hominid hip morphology. This dissertation takes steps toward such a model through comprehensive 3-D landmark analyses of hip size and shape that are interpreted within a functional framework.

For comparison with fossil hominids, data were collected on matched sets of innominates, sacra, and femora — the skeletal elements of the hip — from a globally distributed sample of recent human skeletons. The data were considered as articulated anatomical units and by individual skeletal element. Novel methods and original software employing generalized procrustes analysis, principal component analysis, discriminant function analysis, and multiple regression were used to analyze the data; changes in form along multivariate axes of variation were explored using interactive computer visualization.

The results of these analyses suggest that features of the Neandertal hip that have been cited as evidence of extremely high activity levels or different life histories are more likely to be secondary mechanical and developmental consequences of hyper-arctic body proportions. Neandertal hip morphology is unique, but it is quantitatively and not qualitatively different from that of recent humans. In addition, while australopiths are outside the range of human variation in overall pelvic shape, many other features of their pelves can be predicted, at least in part, by human patterns of scaling related to birth canal depth versus breadth and iliac blade flaring. This dissertation illustrates the importance of considering the skeleton as an integrated whole that is shaped by both evolutionary and mechanically induced developmental adaptation.