produced substantial phenotypic diversity in coyotes and gray wolves, and hybrid zones in the Great Lakes area and southeastern US comprise an intermediate-sized canid, sometimes considered a distinct species. I integrate these observations into diagnosis of how admixture assists and hampers the process of evolution in wolf-like canids.

National Science Foundation, American Kennel Club

Do disparities in ex vivo strain data for the human fibula reflect heterogeneous load conditions or limitations of experimental designs?

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Our laboratory is assembling a large histomorphological data set for interpreting load histories of primate and non-primate limb bones where in vivo strain data are unavailable. We find it nearly impossible to correlate our histomorphological analyses of transverse sections of modern human fibulae with published ex vivo strain data (no in vivo data exist). This is because the "best" studies are highly inconsistent, leading to different load history interpretations. We systematically examined the experimental protocols of all published studies of strain distributions of the human fibula diaphysis to determine if any can be considered more reliable than others. Most cited: Lambert (1971); n=5 limbs, ages not reported. Most rigorous: Thomas et al. (1995); n=9 limbs, 66-94 years. Despite each study using 2-3 strain gauges at mid-diaphysis of fibulae loaded through the tibia, shifts in the neutral axis (separating "tension regions" and "compression regions") are dramatic in Lambert and much less in Thomas (who found consistent anterior [tension] to posterior [compression] bending). Lambert's bones were from limbs amputated for peripheral vascular disease and were loaded without varying foot/ankle position. Thomas used cadaver legs and examined different positions of the foot/ankle with and without loading through the femur. Although Lambert's data are deemed less reliable/realistic, it is possible that some findings reflect true heterogeneity of the strain distribution. Therefore in view of available strain data (all ex vivo), we consider the fibula to be in an "intermediate complexity" load category. This interpretation is consistent with our collagen fiber orientation data.

Using geometric morphometric visualizations of directional selection gradients to investigate morphological differentiation

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Human paleontologists and primate morphologists strive to identify the evolutionary processes that have lead to skeletal differentiation among humans, extant non-human primates, and extinct fossil taxa. We would like to distinguish neutral evolutionary processes (genetic drift, mutation) from natural selection, and in situations for which selection is implicated, identify the aspects of morphology on which selection acted most strongly. The directional selection gradient, first introduced by Lande and Arnold (1983), provides an effective way to investigate these topics, because it relates empirical patterns of differentiation (quantified by between-group differences) and integration (quantified by within-group variance/covariance) to quantitative evolutionary theory.

Here we present novel approaches for visualizing selection gradients based on the landmark and semi-landmark data typically collected by physical anthropologists; and for comparing these gradients to those expected for neutral differentiation. Landmark data are challenging to work with in this context because there are many variables, there are often more variables than cases, and the variables cannot be considered separately from each other. However, because landmarks directly reflect the geometry of the object, they allow for intuitive visualizations of selection gradients.

We explore these approaches with a dataset of 347 3-D landmarks and semi-landmarks recorded on the crania of 260 individuals (112 humans, 67 common chimpanzees, 36 bonobos, 45 gorillas). Preliminary results indicate, perhaps surprisingly, that neutral differentiation results in very plausible selection gradients. Nonetheless, the gradients calculated between humans and the other taxa can be confidently distinguished from neutral gradients.

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Gait ontogeny and the avoidance of impact forces

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Humans habitually employ a heel-striking walking gait, although not consistently before three years of age. This study explores the ontogeny of a walking heel-strike (HS) to better understand why this hallmark of adult locomotion is not reliably present in early gait development. Research suggests that avoiding a heel strike while running can significantly reduce violent impact forces known as the impact transient (IT). Our earlier research has shown that non-heel-strike (NHS) waking in adults also reduces IT forces (HS_{IT}=0.56±0.13BWs; NHS_{IT}=0.14±0.22BWs, p<0.0001). We collected kinematic and kinetic data from a sample of children aged 11-102 months (n=27) and examined changes in impact forces with age and foot posture. A mature (>42 months, n=14) and immature (<42 months, n=13) gait group were separated based on gait developmental timelines to examine patterns in foot posture, highlighting significant variation in ground contact location in young children. While walking, children generated ITs higher (on average) than adults ($mature_{IT}$=0.77±0.23BWs, p=0.005, $immature_{IT}$=0.77 ±0.21BWs, p=0.004). Location of ground contact (HS vs. NHS) predicted the magnitude of impact force in the immature group (R^2=0.54, p=0.004) before (in the mature group) average foot posture converged upon that seen in adults. Therefore, it is possible that early in locomotor ontogeny, children avoid HS gaits to reduce these violent impact forces, possibly protecting their developing skeletal anatomy from high loads. Further, we discuss implications for the development of adult foot morphology and the impact of HS walking on hominin pedal morphology.

A Morphometric Approach for Assessing Cranial Vault Modification in Middle Cumberland Region Crania

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Cranial vault modification (CVM) has long interested anthropologists as a physical manifestation of the intersections between culture and biology. Traditional diagnosis of CVM has concentrated on location and means of flattening; however, this is a subjective method dependent upon observer assessment of shape. In many cases it is difficult to distinguish modification from natural variation. This project provides a more empirical method of CVM determination through morphometric analysis of cranial landmarks, specifically 3D scanning. This project examines CVM within the Arnold (n=20) and Averbuch (n=60) late prehistoric skeletal samples from the Middle Cumberland Region of Tennessee. A NextEngine 3D Scanner is used to create high-resolution cranial models with accurate shape data. Both midline and lateral cranial landmarks are used to examine the degree and asymmetry of cranial flattening. A Procrustes analysis is performed in order to translate, rotate, and scale the landmark data, followed by a Jenks natural breaks method for detecting categories within the sample. Preliminary analysis of relative position of point data indicates that quantifiable spatial differences can be observed between the landmark distributions of modified and unmodified crania. The implications of this project's method may more accurately capture differences produced by CVM and provide a more empirical basis for archaeological interpretations involving modified crania.