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Differences in Strength and Structure among Ape and Human Thoracic Vertebrae

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Humans are unique among the hominoids in being susceptible to osteoporosis-related spontaneous vertebral fractures. Because severe bone loss has been observed in wild apes, differences in bone volume alone are an incomplete explanation for differences in vertebral fracture incidence among hominoids. We examined compressive strength and trabecular microarchitecture within the T8 vertebral bodies of young adult humans, chimpanzees, gorillas, orangutans and gibbons (n=6 each, mixed sex) using quantitative computed tomography and micro-computed tomography images. Finite element models indicated that while all species have a relationship between bone mass and compressive strength, humans have a significantly lower compressive strength than would be expected for bone mass. Because the relationship between bone mass and body mass did not differ among species, this suggested that there were biomechanically important differences in structure between humans and apes. Intra-vertebral variation in trabecular bone distribution and degree of anisotropy was similar among the hominoids. All species displayed trends toward higher bone volume near the endplates and lower bone volume at the center of the vertebral body, but only orangutans and chimpanzees demonstrated a significant difference ($p<0.05$). Lastly, the vertebral shell of humans was thinner than would be expected for body mass. These results indicate that during young adulthood, differences in bone strength already exist between humans and apes, but there are only minor differences in these vertebral microarchitecture parameters, suggesting that differences in vertebral fracture susceptibility may be a result of differences in vertebral shell thickness or patterns of age-related bone loss.