Letters to the Editor

Inverse relationship of osteoarthritis to weight: The bird lesson

Sirs,

Osteoarthritis is the most common form of arthritis in humans (1). Weight has been presumed to be a major factor in its development (2, 3). Prior studies (e.g., 1, 2), however, have not been sufficiently controlled for confounding factors, especially clinically significant joint instability. Rarity of osteoarthritis in free-ranging mammals and different joints affected in captive (versus free-ranging) animals compromises attributions (4-6).

Given the lack of or inverse relationship of osteoarthritis to weight in dinosaurs (4), their purported relationship to birds, the high frequency of osteoarthritis in wild-caught birds and observations previously reported in woodpeckers (7), there is a unique opportunity to critically examine the effects of weights. Hawks, falcons and pigeons were selected to assess effects of weight within families with very different lifestyles, predator and prey.

The articular skeletons of adult hawks, falcons and pigeons were examined from the following collections: Academy of Natural Sciences of Philadelphia; American Museum of Natural History, New York City; Carnegie Museum, Pittsburgh; Cleveland Museum of Natural History; Field Museum of Natural History, Chicago, IL; Los Angeles County Museum; Michigan State Museum, East Lansing; Musee et Service d'archeologie de Neuchafel Laboratoire d'Archeozoologie, Neuchafel, Switzerland; Natural History of Berne, Switzerland; Royal Ontario Museum, Toronto; Science Museum of Minnesota, Minneapolis; United States National Museum, Washington, D.C.; University of California at Berkeley; University of Manitoba; University of Michigan, Ann Arbor; University of Winnipeg; and Yale Peabody Museum, New Haven. All animals were categorized as either free-ranging (80% of those studied) or captive (caged or aviary).

Defleshed skeletons were surveyed for visible evidence of articular and periarticular joint and spine pathology. Osteoarthritis was identified on the basis of synovial-lined joint remodeling with spur (osteophyte) formation (4, 8). The validity of diarthrodial joint osteophytes for recognition of osteoarthritis has been documented across vertebrate orders (4, 5) including dinosaurs (4), which some view as bird ancestors, and so is equally as applicable to birds as to humans.

Chi square analysis was performed to determine significance of variation among two bird families, hawks (falconidae including Falco and Buteo), and herons (Ardeidae). As bird growth and weight accretion cease at time of epiphyseal closure and are independent of subsequent aging, body mass measurements are directly comparable, as derived from Dunning and Del Hoyo's groups have documented (9, 10). Regression analysis was performed to determine the relationship of body mass to frequency of osteoarthritis.

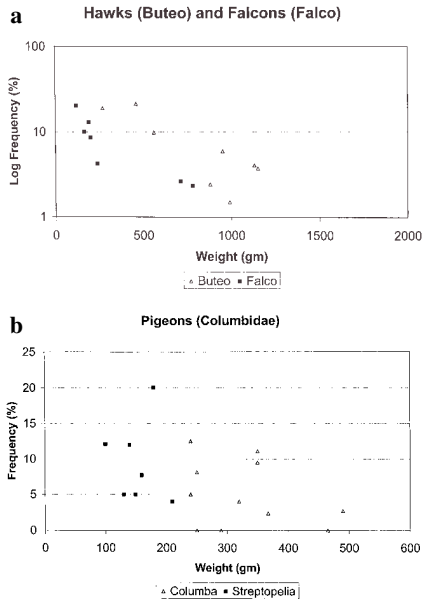

Fig. 1. Frequency of tibiotarsal (ankle) osteoarthritis in hawks (**a**) and falcons (**b**), as a function of weight.

Osteoarthritis was common among examined pigeons and hawks, limited in distribution to tibiotarsal joints (ankles). No evidence of osteoarthritis was found in any other joints of the examined species. Osteoarthritis was more common in pigeons than in birds of prey (Chi square = 56.314, $p < 0.0001$). Figure 1 reveals the frequency of osteoarthritis as a function of typical species body mass (10,11) for 2961 hawks and 2747 pigeons (Fig. 1). An inverse relationship is documented.

The morphology of the tibiotarsal joint in birds is analogous to the knee in humans. Given the prominence of the knee as a target of osteoarthritis in humans (1, 2, 4), it is perhaps not surprising that when osteoarthritis occurs in birds, it affects this joint. Limitation to the ankle suggests the likelihood of biomechanical derivation of the phenomenon.

Recognition of an inverse relationship between weight and frequency of osteoarthritis certainly negates any major role for weight and stimulates a more complex analysis of what factors are really pertinent. Curiously, inverse relationship to weight also infers inverse relationship to longevity, as smaller animals (especially birds) do not live as long as larger ones. Osteoarthritis appears to be dependent upon how they live.

Higher frequency of osteoarthritis in pigeons than in birds of prey suggests trauma (e.g., strikes on prey) is not the significant factor in development of osteoarthritis in birds. Perhaps ground time is more important? Hereditary factors (e.g, collagen defects) may account for 1% of osteoarthritis in humans, as does abnormal joint structure (e.g., dysplasia). Such are subjects for future study, to assess if they account for any more significant contribution to avian osteoarthritis than the limited epidemiologic impact documented in mammals. Future advances in understanding of osteoarthritis may be 'pinned' on what else we can learn from analysis of osteoarthritis in birds.

Acknowledgments

Appreciation is expressed to Drs. Laura Abraczinskas, Christine Blake, Carla Cicero, Christopher Conroy, James Dean, Kimball Garrett, Marcel Guentert, Janet Hinshaw, Robert Hobson, Brad Livezey, Mike MacKinnon, Timothy O. Matson, Werner Mueller, Glen Murphy, Dick Oehlenschlager, Storrs Olson, Nate H Rice, Paul Sweet, Greg Watkins-Colwell, David Willard and Kristof Zyskowski for permitting and assisting with access to the collections they curate.

B. ROTHSCHILD[1,2], *MD*[*]

R. PANZA[2], *MS*

[1]*Arthritis Center of Northeast Ohio and Northeastern Ohio Universities College of Medicine, 5701 Market, Youngstown, Ohio and* [2]*Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, USA.*

[*]*To whom correspondence and reprint requests should be directed. E-mail: bmr@neoucom.edu*

References

1. PELLETIER JP, MARTEL-PELLETIER J, HOWELL DS: Etiopathogenesis of osteoarthritis. *In* KOOPMAN WJ (Ed.): *Arthritis and Allied Conditions*. 14th ed. Baltimore, Williams & Wilkins 2000: 2195-245.
2. MESSIER SP, LOESER RF, MILLER RF, MORGAN GD, REJESKI TM, SEVICK WJ: Exercise and dietary weight loss in overweight and obese older adults with knee osteoarthritis: The arthritis, diet, and activity promotion trial. *Arthritis Rheum* 2004; 50: 1501-10.
3. SHARMA L, SONG J, FELSON DT, CAHUE S, SHAMIYEH E, DUNLOP DD: The role of knee alignment in disease progression and functional decline in knee osteoarthritis. *JAMA* 2001; 286: 188-95.
4. ROTHSCHILD BM, MARTIN LD: *Paleopathology: Disease in the Fossil Record*. London, CDC Press 1993.
5. PRITZKER KP: Animal models for osteoarthritis: Processes, problems and prospects. *Ann Rheum Dis* 1994; 53: 406-20.
6. ROTHSCHILD BM, HONG N, TURNQUIST JE: Skeletal survey of Cayo Santiago rhesus macaques: Osteoarthritis and apical plate excrescences. *Semin Arthritis Rheum* 1999; 29: 100-11.
7. ROTHSCHILD BM: Fortuitous photograph of the most arthritis-afflicted of the woodpeckers. *Arch Intern Med* 2005; 165: 2037.
8. ALTMAN R, ASCH E, BLOCH D *et al.*: Criteria for classification and reporting of osteoarthritis: Classification of osteoarthritis of the knee. *Arthritis Rheum* 1986; 29: 1039-49.
9. DEL HOYO J, ELLIOTT A, SARGATAL J, DEL-HOYO J, CABOT J: *Handbook of the Birds of the World*. Barcelona, Lynx Edicions 1992.
10. DUNNING JB JR (Ed.): *CRC Handbook of Avian Body Masses*. Boca Raton, CRC Press 1993.