Seasonal Changes in Bone Mineral Density in the Northern Red-Backed Vole: A Potential Model Organism for Disuse Osteoporosis

Disuse osteoporosis is a reduction in bone density due to a lack of mechanical stress on bones. It can be caused by prolonged bed rest, localized immobilization due to spinal cord injury or stroke, or the application of a cast to treat fractures. Small non-hibernating high-latitude mammals are likely to experience analogous reductions in bone density as they maintain body temperature but severely reduce movement during winter to save energy. Our aim was to test whether one such mammal, the northern red-backed vole, *Clethrionomys rutilus*, could be used as a model for studies of disuse osteoporosis by testing whether this species' bone density changes seasonally. The bone mineral density of the long bones of northern red-backed voles that had been collected over a period of 12 months, were measured using a dual energy x-ray apparatus (DXA). Bone mineral density was correlated with bone length and photoperiod. It was highest at times of high activity (summer) and lowest at times of low activity (winter). This suggests that bone density in the northern red-backed vole is reduced in winter as a result of its restricted activity in a manner analogous to disuse osteoporosis in humans. The northern red-backed vole is likely to make an excellent model organism for studies of disuse osteoporosis.

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Background

Disuse osteoporosis is a reduction in bone density due to a lack of mechanical stress on bones. It can be caused by prolonged bed rest, localized immobilization due to spinal cord injury or stroke, or the application of a cast to treat fractures.[1] Small non-hibernating high-latitude mammals, such as voles,

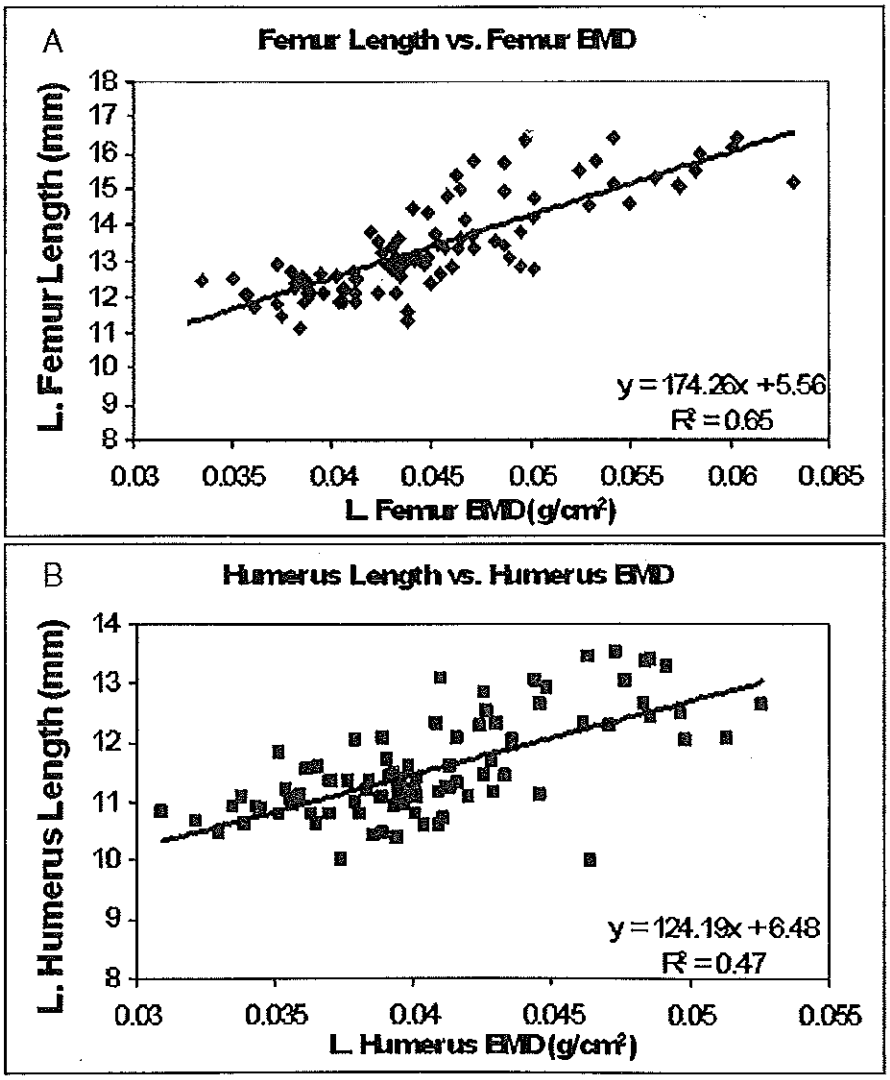

Fig 1. Correlation between bone density and bone length for the left femur and left humerus of the northern red backed vole, *Clethrionomys rutilus*

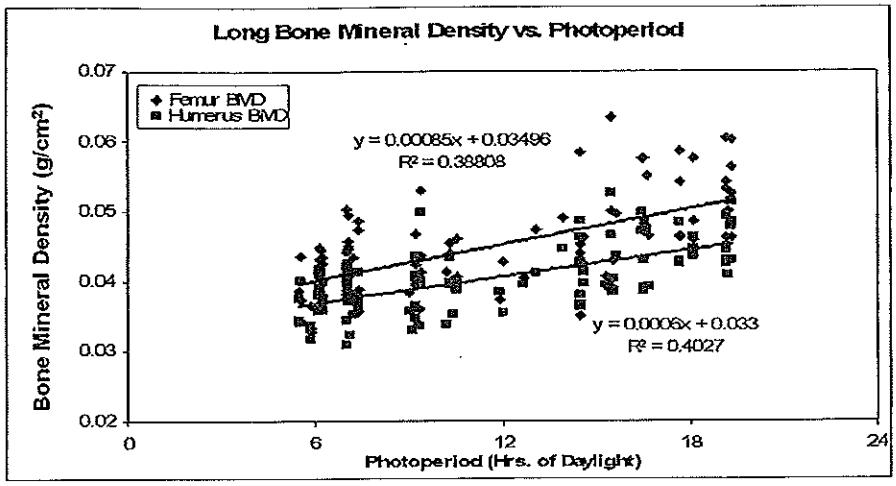

Fig 2. Effect of photoperiod on the bone mineral density of the left femur and left humerus of the northern red backed vole, *Clethrionomys rutilus*. 18 or more hours of daylight per day = mid summer, 6 or less hours of daylight per day = mid winter

are likely to experience analogous reductions in bone density as they maintain body temperature but severely reduce movement during winter to save energy.[2] These animals provide potential models for studies of disuse osteoporosis as they are small, easy to handle and abundant. They are also easy to keep and to breed in captivity in large numbers.[3] Non-hibernating mammals, like voles, mimic the human condition more closely than hibernating mammals as they maintain their body temperature, metabolism, heart rate and normal body functions throughout the year and restrict, but do not eliminate, movement during winter. Our aim was to test whether one such mammal, the northern red-backed vole, *Clethrionomys rutilus*, could be used as a model for studies of disuse osteoporosis by testing whether this species' bone density changes seasonally.

METHODS

Adult red-backed voles were collected from Chugach State Park, Alaska between November 2004 and January 2007 (61°N). We dissected out two long bones (left humerus and left femur) from each vole. The length of each bone was determined using digital calipers and the bone mineral density (BMD) was determined using a dual energy x-ray apparatus (PIXI Mus2: Lunar/GE).[4]

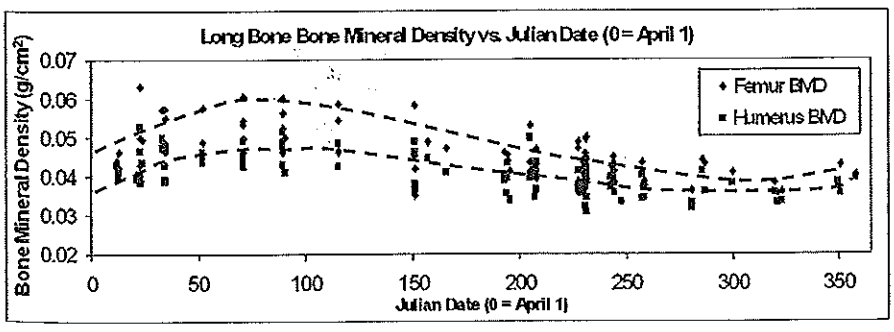

Fig 3. Effect of season on the bone mineral density of the left femur and left humerus of the northern red backed vole, *Clethrionomys rutilus*. 0 = April 1 (early spring), 100 = 9 July (mid summer), 200 = 17 October (mid autumn), 300 = 25 January (mid winter)

RESULTS

Bone length was correlated with bone density (Figure 1A–B), indicating that when bones were denser, they were also longer. Bone density was correlated with photoperiod (Figure 2) and with season (Figure 3). It was highest at times of high photoperiod (long day length, summer) and lowest at times of low photoperiod (short day length, winter).

DISCUSSION

Bone mineral density was correlated with photoperiod and changed with season in a manner that reflected the voles' activity levels. It was highest at times of high activity (summer, Figures 2, 3) and lowest at times of low activity (winter, Figures 2, 3). As bone density was also correlated with bone length (Figure 1), bone mineral retention was higher than bone density suggests when bone density was high and lower than bone density suggests when bone density was low.

These results demonstrate that bone mineral density and bone mineral retention in the northern red-backed vole are reduced during winter, a period of naturally restricted activity for this species.[2] This reduction is likely to have occurred in a manner analogous to the reduction seen in disuse osteoporosis in humans. Given that this species also appears to undergo activity-related bone mineral reduction in winter, and they are small, easy to handle and easy to keep and breed in captivity,[3] it has the potential to be an excellent model organism for studies of disuse osteoporosis.

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