POST-HIBERNATION BLACK BEARS (URSUS AMERICANUS) DO NOT DEMONSTRATE CORTICAL BONE LOSS COMPARED TO PRE-HIBERNATION BEARS DESPITE 6 MONTHS OF DISUSE

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INTRODUCTION

Disuse typically causes unbalanced bone remodeling which leads to bone loss and reduced bone strength (Li et al., 2005). However, previous studies suggest that bears are able to prevent bone loss during disuse associated with hibernation. Cortical bone geometry and strength are preserved in hibernating grizzly bears, and interestingly, intracortical porosity is lower and mineral content is higher in hibernating compared to active grizzly bears (McGee et al., 2008). However, previous sample sizes were small (n = 4 bears in each season), limiting the conclusions that could be drawn from the data regarding the effects of hibernation on bear cortical bone structure and strength. Here we investigated bone properties in a large sample of pre- and post-hibernation black bears to comprehensively determine the effects of hibernation on bear cortical bone.

METHODS AND PROCEDURES

One femur was obtained from each of 65 black bears (*Ursus americanus*) killed during the fall and spring hunting seasons in Utah; 18 were from female bears (mean age = 8.4 ± 5.5 yrs) and 47 were from male bears (mean age = 5.6 ± 3.6 yrs). Age and sex distributions were comparable between seasons. Post-hibernation bears had remobilized following 6 months of disuse for approximately 1-4 weeks.

Bones were loaded to failure in three-point bending, after which the midshaft of the diaphysis was reconstructed and embedded in methyl methacrylate. Midshaft cross-sections were exposed with a diamond saw and digitized with a digital camera. Bone geometrical properties including moments of inertia about the mediolateral and anteroposterior axes (I_{ML} and I_{AP}, respectively), maximum moment of inertia (I_{max}), periosteal, cortical, and endosteal bone areas (Ps.Ar, Ct.Ar, and Es.Ar, respectively), and endosteal area fraction (Es.Ar/Ps.Ar) were calculated with Scion Image (Frederick, MD) and a custom macro. Beam theory was used to calculate whole bone ultimate stress (σ_U), energy to failure (U), and modulus of toughness (u). Diaphyseal segments proximal to the reconstructed midshaft were used to quantify ash fraction (a measure of mineral content). Sections of the diaphysis distal to the reconstructed midshaft were histologically processed for a sampling of bears from each season (n = 13 pre-hibernation and 16 post-hibernation). Slides were prepared with basic fuchsin and were used to quantify intracortical porosity at 40x magnification. Bone properties were compared between pre- and post-hibernation bears with ANCOVA, treating age as the covariate. Males and females were pooled for statistical analyses since group distributions were similar.

RESULTS

There were no differences in bone geometrical properties between pre- and post-hibernation bears ($p > 0.458$). A representative plot is shown in Figure 1.

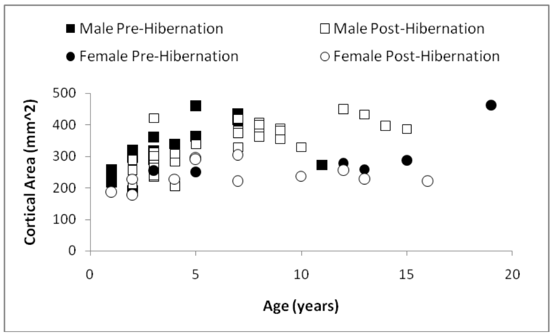

Figure 1. Cortical area was not different between fall and spring bears ($p = 0.699$)

There were no differences in bone mechanical properties or ash fraction between pre- and post-hibernation bears (Table 1). Intracortical porosity was significantly lower ($p = 0.044$) in post- compared to pre-hibernation bears (Table 1).

Property	Pre-hib	Post-hib	Pre- vs. Post- ANCOVA p-value
σ_U (MPa)	238 (42)	233 (27)	0.519
U (J)	46 (15)	43 (16)	0.500
u (mJ/mm^3)	6.1 (1.5)	5.5 (1.6)	0.261
ash fraction	0.694 (0.011)	0.696 (0.010)	0.797
porosity (%)	6.2 (2.6)	4.7 (1.8)	0.044

Table 1. Means & standard deviations for cortical bone properties in pre- and post-hibernation bears.

DISCUSSION

In most animals, disuse causes bone loss because bone remodeling processes become imbalanced. In contrast, post-hibernation black bears did not demonstrate bone loss compared to pre-hibernation bears, since bone geometrical, mechanical, and mineral properties were not different, and porosity was significantly lower in the post-hibernation bears. This is likely because hibernating bears experience decreased, but balanced, intracortical remodeling (McGee et al., 2008), which would contribute to the preservation of cortical bone structure and decrease in bone porosity during hibernation. The decrease in bone remodeling activity during hibernation may be a result of energy conservation and recycling mechanisms used to survive prolonged periods of famine. The results of this study are in agreement with our previous findings in hibernating and active grizzly bears (McGee et al., 2008) and another study which showed that bone cross-sectional area of the forelimb is not different in pre- and post-hibernation black bears (Pardy et al., 2004). The mechanism which prevents bone loss in bears may lead to the development of treatments (e.g., novel PTH peptides) for human osteoporoses. For example, we found bear PTH 1-34 promotes greater anti-apoptotic gene expression in osteoblasts than human PTH 1-34.

REFERENCES

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