MINIMAL MUSCLE ATROPHY DURING HIBERNATION IN CAPTIVE BROWN BEARS

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INTRODUCTION

Previous studies on wild black bears (*Ursus americanus*) have shown skeletal muscle morphology, composition and overall force generating capacity do not differ drastically between late fall and early spring [1, 2]. These findings are surprising in that prolonged inactivity during hibernation should cause significant amounts of atrophy, leading to decreased maximal force and a shift toward faster fiber types.

The amount and characteristics of the seasonal variations in skeletal muscle were not consistent in the previous studies in that the variation in muscle properties ranged from no significant change to a 23% change. Moreover, measurements were made in the late fall, when muscle strength may already be compromised and in the early spring, when physiological changes to regain muscle strength may have already started.

The goals of this study were to confirm that the amount of muscle atrophy in captive brown bears (*U. arctos)* is minimal, similar to that observed in wild black bears. This study will extend previous studies by examining muscle samples between mid-summer (peak activity) and mid-winter (peak inactivity) and characterize twitch dynamics as part of the atrophy measurements.

METHODS

Six captive brown bears from the Washington State University Bear Research Center were studied. The bears hibernated each winter from late October to late March. All protocols were approved by the Institutional Animal Use and Care Committee.

Samples from the *biceps femoris* muscle were collected during the summer and winter. Each sample was connected to a force transducer and fixed hook within an experimental chamber circulating an aerated physiological solution at 37°C. To elicit isometric twitches, a pair of plate electrodes provided field stimulation at a supramaximal voltage. Ten consecutive twitches were recorded. After 5 minutes of rest, twitches were again recorded and this procedure was repeated for a total of three twitch trains. Individual twitches were analyzed for half rise time, time to peak, half decay time, and total twitch time.

After the electrical stimulation recordings, the sample was flash frozen in liquid nitrogen. A piece of the sample was processed for total protein concentration by a standard Bradford method. Another piece was sectioned and stained for ATPase activity. The sections were digitally photographed at a low magnification. Four hundred random fibers were classified as type I or type II by staining intensity. Each fiber's cross-sectional area was measured.

Statistical analysis was performed with a two-tailed, non-parametric, Wilcoxon Signed Rank test for seasonal differences. Significance was accepted at the $p<0.05$ level.

RESULTS AND DISCUSSION

Satisfactory twitch data was obtained from summer and winter samples in five bears (Figure 1). Although all values in winter were higher than the corresponding summer values (Table 1), only half rise time was statistically different ($p = 0.043$).

Average protein concentration was 194.2±7.8 mg/g in the summer and decreased to 178.2±7.6 mg/g during hibernation ($p = 0.028$). Slow and fast fiber percentages were 48.0 and 52.0±9.9% respectively in summer and 47.7 and 52.3±7.7% in winter, indicating no seasonal difference. Cross-sectional area showed no significant differences between summer (10074±2618 μm^2) and winter (9125±958 μm^2) for slow fibers and between summer (9450 ±1774μm^2) and winter (9421±1870 μm^2) for fast fibers.

These results agreed with a study which showed minimal skeletal muscle atrophy between seasons in wild black bears. For example, the time to half maximal force in the twitch contractions increased in winter relative to summer samples. This is in contrast to the faster twitch dynamics in muscle undergoing disuse atrophy [3]. Our results also shows that skeletal muscle in bears does not change between the periods of peak use and of peak disuse.

SUMMARY/CONCLUSIONS

We measured the amount of atrophy between mid-summer and mid-winter in muscle samples from six captive brown bears and found minimal seasonal differences. In fact, the twitch dynamics were slightly slower in winter, opposite to that expected from muscle that does not have much weight-bearing activity. These findings merit further investigation as to the mechanisms behind this intriguing ability of hibernating bears.

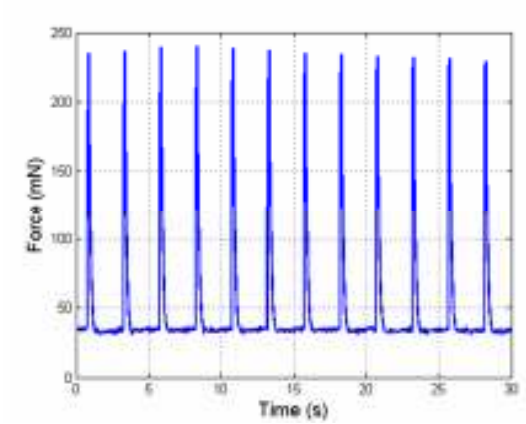

Figure 1: Isometric twitches from a bear *biceps femoris* sample.

REFERENCES

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Table 1: Average twitch characteristics for 5 bears.

Season	Half Rise Time(s)	Time to peak (s)	Half Fall Time(s)	Total Twitch Time(s)
Summer	0.019	0.067	0.126	0.392
Winter	0.029	0.081	0.132	0.429