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Skeletal Impacts of Dual *in vivo* Compressive Axial Tibial and Ulnar Loading

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INTRODUCTION

- Compressive axial tibial loading is an established method for inducing bone formation in a variety models [1].
- Tibial loading is favored over compressive axial ulnar loading since the load is not directly applied to the bone and the tibia has a better mix of cortical and trabecular bone [1,2,3].
- By combining these methods in a single animal, the number of animals needed per study could be reduced by half.

AIM

- Develop a combined compressive axial tibial and ulnar loading technique capable of inducing an anabolic response in both bones to reduce the number of animals required per study.
- Evaluate the efficacy of this dual-loading method across both sexes and two age groups

METHOD

ANIMALS AND STUDY DESIGN

n = 68 C57BL/6J mice (n = 34 males, n = 34 females)
Young: 9 wks old upon arrival
Old: 19 wks old upon arrival

LOADING: (11 wks – 15 wks) & (21 wks – 25 wks)

- n = 5 per group utilized for strain gauge calibration to calculate required load to induce 2050 με, Table 1
- Right Tibiae and Left Ulnae loaded 3x/week for 4 wks

	Female (N)		Male (N)	
	Young	Old	Young	Old
Ulna	2.6	2.2	3.1	3.3
Tibia	11.8	13.1	14.9	14.8

Table 1. Calculated compressive load values for various loading groups and limbs

MICROCOMPUTED TOMOGRAPHY

- R/L ulnae and tibiae scanned at 9.8 μm isotropic voxel size, 0.7°rotation, 2 frame averaging using a 0.5 Al filter (SkyScan 1172)
- Cortical Regions of Interest (ROI) - Tibia: 37.5% of total bone length from proximal end; Ulna: 50% region of total bone
- Trabecular ROIs – Tibia: began at proximal growth plate and ended 1mm distal to plate; Ulna: Began at proximal point of olecranon process and ended 6% of total bone length proximal to process

MECHANICAL TESTING

- R/L Tibiae and ulnae tested using 4- point and 3-point bending to failure, respectively

RESULTS

ANALYSIS:

- Repeated-measures two-way ANOVA
- * main effect of loading
- # main effect of age

CORTICAL ANALYSIS (FIG. 1)

A) Tibiae maximum moment of inertia (Imax) increased due to loading in all groups

B) Ulnae Imax increased due to age in females, but loading had no effect

TRABECULAR ANALYSIS (FIG. 2)

A) Tibiae bone volume/total volume (BV/TV) increased in all groups due to loading, but decreased due to age in all groups

B) Ulnae BV/TV decreased due to age in all groups, but was not impacted by loading

MECHANICAL ANALYSIS (FIG. 3)

A) Male tibiae structural level mechanical properties did not change due to loading and tissue level mechanical properties suffered. Yet, multiple ulnar structural level and tissue level mechanical properties improved with loading.

B) Female tibiae structural level and tissue level mechanical properties underwent significant improvements due to loading. Ulnar structural level and tissue level mechanical properties were not changed with loading.

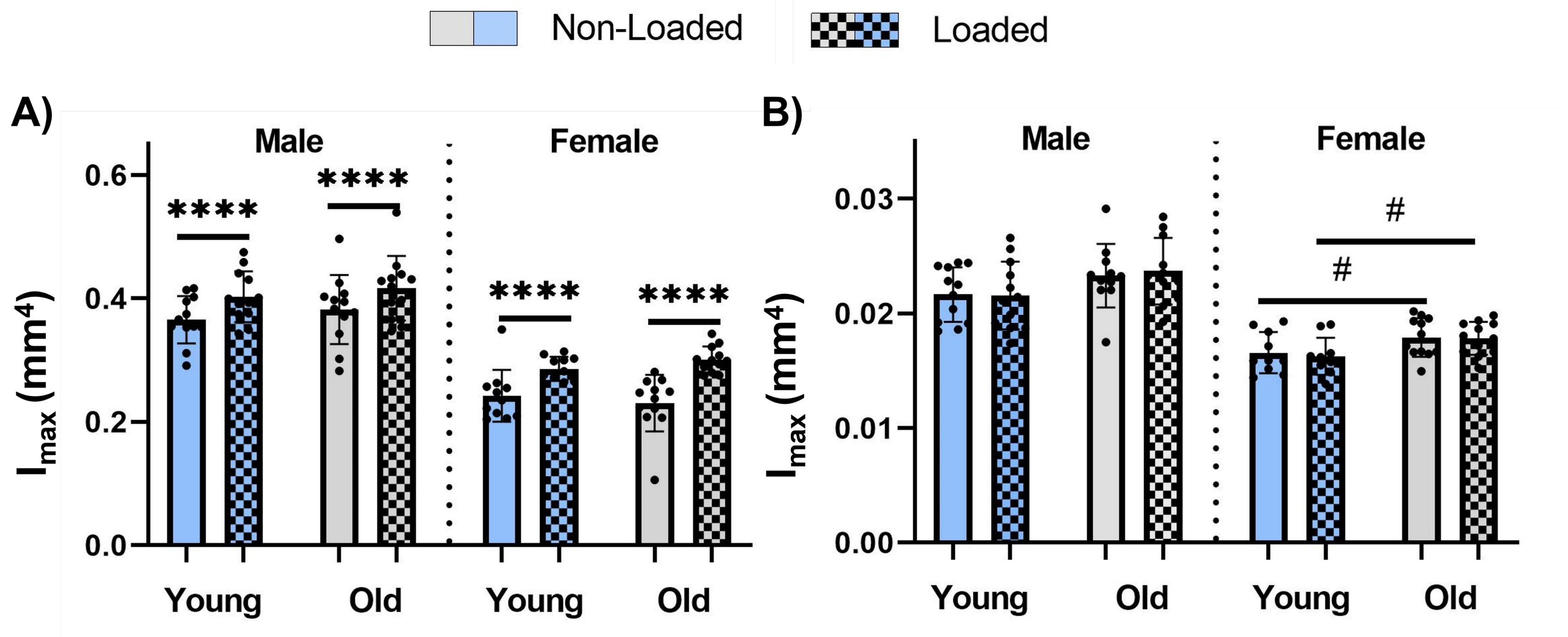

Fig. 1. A) Tibial and B) Ulnar maximum moment of inertia values (Imax) calculated from μCT scans

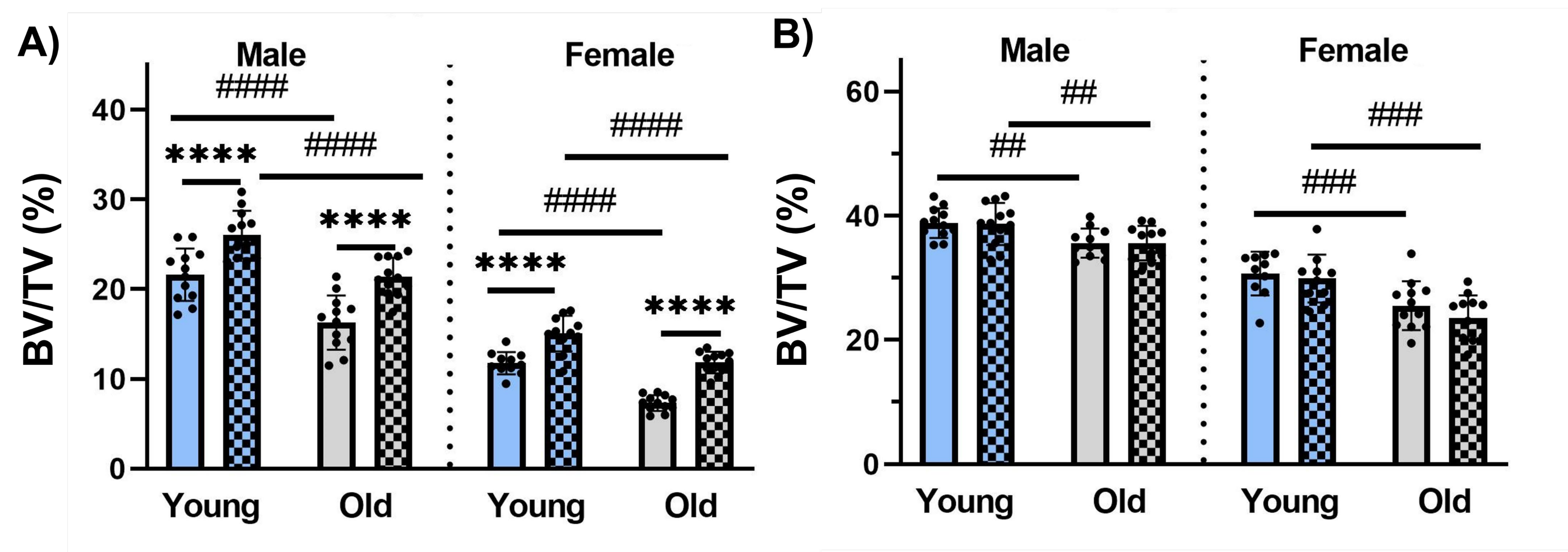

Fig. 2. A) Tibial and B) Ulnar bone volume/total (BV/TV) calculated from μCT scans

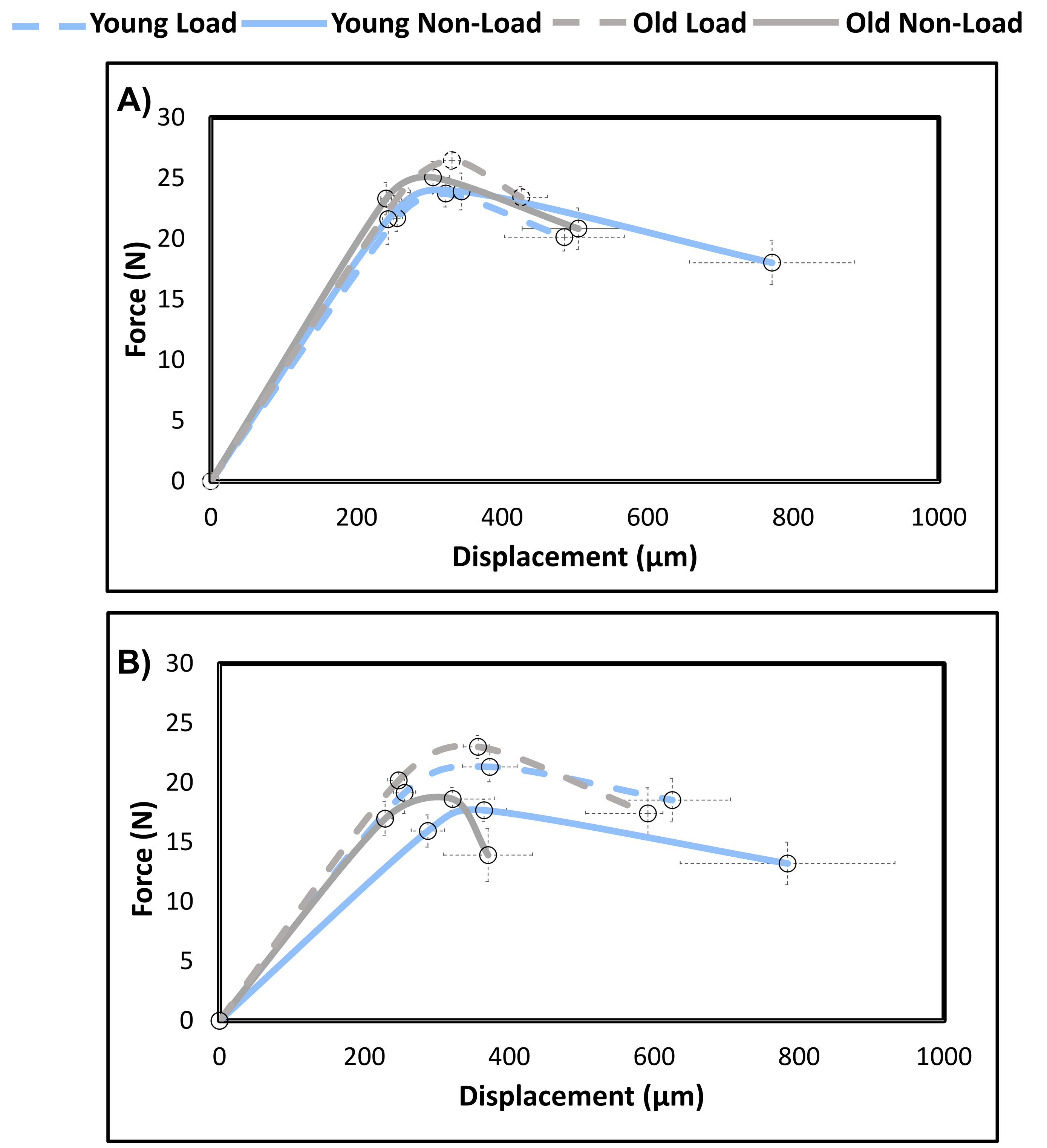

Fig. 3. A) Male and B) female tibia 4-point structural level mechanical properties. Data represent mean ± SEM

CONCLUSIONS

- Compressive axial tibial loading improved numerous cortical and trabecular properties in the right tibiae of males and females
- Compressive axial ulnar loading improved a single cortical property but had no impact on other cortical properties and trabecular bone properties
- Whole-bone mechanical properties were improved in female tibiae but not in the male tibiae with loading. In male ulnae select whole-bone mechanical properties were improved with loading but this did not occur in female ulnae with loading.
- The lack of overall architectural and whole-bone mechanical changes in the loaded ulnae compared to the improvements observed in the tibiae demonstrate that ulnar and tibial loading may not be used interchangeably

REFERENCES

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