The Effect of Chronic Limb Loading on the Tibialis Cranialis Moment Arm in Guinea Fowl

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Summary

We examined the effect of chronic limb loading during the growth period in guinea fowl. Limb loaded (LL) animals had 3.5% body weight applied unilaterally to the distal limb throughout the growth period. Following sacrifice, we measured the moment arm of the tibialis cranialis (TC) muscle with the tendon excursion method. Our results demonstrate that there were no significant differences in moment arms between the control (CON) and LL groups, but significant differences between sides were found for both groups.

Introduction

The moment arm of a muscle, which influences the muscle's mechanical advantage is an important parameter in muscle function [1]. It is well established that muscles adapts to chronic loading stimulus, but whether moment arms demonstrate the similar adaptation is unknown.

We examined this question using an avian model (guinea fowl; *Numida meleagris*). In a previous study done in our lab, the Achilles tendon moment arm was found to be larger in guinea fowl that underwent high acceleration training during the growth period [2]. To address this question in the present study, we subjected animals to a chronic limb loading stimulus that targeted the TC muscle. We hypothesized that the moment arm of the TC muscle would be larger on the loaded side in the LL group when compared to either the unloaded side or to the moment arms of CON birds.

Methods

Twenty guinea fowl were randomly assigned to the CON group (n=10) or the LL group (n=10). From 2 wks to 16 wks of age, LL animals were unilaterally loaded with a mass equal to 3.5% of their body weight placed above the right ankle. In addition, all animals underwent twenty minutes of training 3 times per week in which they were herded around a large circular pen. Animals were euthanized at 16 wks of age.

The TC muscle moment arms on both sides in both the LL and control groups were measured using the tendon excursion method. The limb being tested was secured using bone clamps (Fig. 1). Bone pins were drilled into the femur, tibiotarsus and tarsometatarsus segments. Clusters of four retroreflective markers fastened to each bone pin were tracked by a 6-camera motion analysis system. A cable transducer was connected to the TC tendon via a suture to measure tendon travel. The ankle joint was cycled through its range of motion while marker coordinates and tendon travel data were recorded. Linear fits were performed to tendon excursion versus ankle angle. Ankle flexion moment arm was computed as the derivative of tendon excursion versus ankle joint angle.

Results and Discussion

At this writing we have tested and analyzed data from 7 LL and 8 CON birds. A mixed-effects general linear model revealed no significant difference between the moment arms of CON and LL birds ($p=0.661$). Significant bilateral differences ($p<0.001$) were found for both groups, with the right-side moment arm consistently found to be larger (Fig. 1); there was no significant interaction between side and group ($p=0.918$) the right TC moment arm was larger compared to the left. The difference between sides we found for CON birds was unexpected, and we are presently investigating whether this can be attributed to experimental artifact.

Figure 1: Measurement of tendon excursion and limb kinematics.

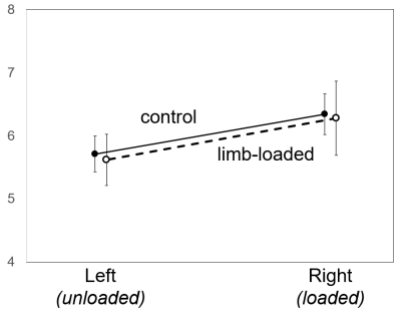

Figure 2: Average moment arms for control and limb loaded animals. For the limb loaded group the right side was loaded.

Conclusions

The results did not support our hypothesis. While there were differences between the loaded and unloaded limbs, we found essentially the same bilateral differences for CON birds. Whether this result is due to true morphological differences or an experimental artifact is currently under investigation.

Acknowledgments

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References

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