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THE EFFECTS OF DIET INDUCED OBESITY ON THE FORCE-LENGTH RELATIONSHIP IN RAT SOLEUS

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INTRODUCTION

Obesity is associated with chronic inflammation, which has been shown to affect the integrity of musculoskeletal tissues [1]. Previous data from our group suggests that obesity can result in intramuscular fat deposition [1]. It is unclear if this structural alteration has functional consequences, as the implications of obesity on muscle mechanics are not well understood. Therefore, the purpose of this study was to quantify the active force produced by soleus muscles of obese and non-obese rats at a range of muscle lengths. As the inclusion of fat into the muscle fibers will leave less room for contractile proteins, we hypothesized that obese rats will produce lower forces normalized to muscle mass at every length than non-obese control rats.

METHODS

Fourteen rats were randomly allocated to a 12-week diet: either an obesity-inducing high fat high sucrose diet (DIO, 40% fat, 45% sucrose, n=8) or a standard chow diet (chow, 12% fat 0% sucrose, n=6). Prior to surgery, body composition was evaluated using dual energy X-ray absorptiometry. Custom-made tibial nerve cuffs were surgically attached to the right tibial nerve of each animal. The soleus was exposed, mechanically isolated, and clamped to a force transducer. The muscle was then stretched to a predetermined length and electrically stimulated at 3 times the motor unit threshold (50Hz) and the force output was measured [3]. Force tracings were digitized using WINDAQ® software. Passive, active, and total forces produced by the soleus were normalized to the maximum in vivo length of each animal. Forces were averaged into 5% length intervals within each animal. Students t-tests or a two-way ANOVA were conducted between groups, and a Bonferroni correction was used as needed, $\alpha=0.05$.

RESULTS

DIO rats had increased body mass (DIO 816.4 ± 30.1g, chow 645.0 ± 28.3g; $p<0.05$) and body fat (DIO 39.2 ± 1.3%, chow 21.8 ± 2.1%; $p<0.05$) compared to chow-fed rats. Soleus mass (DIO: 0.28 ± 0.01 g, chow: 0.26 ± 0.11 g, p=0.32), was similar between the two groups. Absolute peak isometric force was similar between the two groups (DIO: 2.58 ± 0.10 N, chow: 2.18 ± 0.34 N, p=0.23). Active isometric force normalized to soleus mass was significantly higher in DIO group rats at every muscle length (*Figure 1,* $p<0.05$).

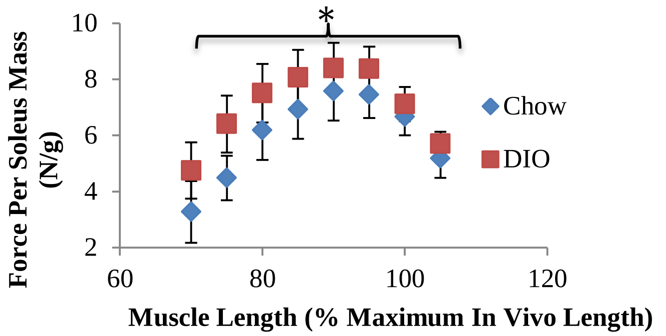

Figure 1: Active isometric force was higher across all points in the obese (DIO) group compared to chow. Data are shown as mean ± standard error of the mean. * Indicates $p<0.05$ between groups.

DISCUSSION AND CONCLUSIONS

On average, DIO rats produced more active force at a given normalized length and soleus mass than chow rats, a finding that refutes our original hypothesis. Since optimal length occurs at the same relative muscle length for both groups, and since the decline in force from maximum is similar between groups, it appears that fascicle length, and an associated shift in the force-length relationship cannot explain our results. Results of differences in the force-velocity relationship (not shown here) suggest that the DIO rats may have a higher proportion of fast twitch fibres, but the relative force among slow and fast fibres is similar, and thus also should not affect these results. The results suggest that the force per cross-sectional area is higher in muscles from obese compared to lean rats, a finding that defies explanation at this time and needs thorough investigation in the future. Histology and tests looking at fibre and cell level muscle structures may provide more insight.

REFERENCES

1. Collins et al. *Osteoarthritis and Cartilage*. In Press
2. Ciapaite et al, *J. of Nut Biochem.* **26**:155-164, 2015.
3. Hisey et al. *J Biomech* **42:** 1488-1492, 2009.