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FUNCTIONAL EFFECTS OF DIET INDUCED OBESITY ON PERMEABLIZED RAT MUSCLE FIBRES

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INTRODUCTION`

Muscle performance is determined by the metabolic, calcium handling, and sarcomeric characteristics of its constituent fibres. Diet induced obesity (DIO) may influence contractile performance in whole muscle, but little is known about the effects of DIO at the single fibre level. Particularly, how DIO might influence the contractile characteristics of single fibres free from the influence of metabolic or calcium handling properties is not established. There is some limited evidence to suggest that DIO may influence the sarcomeric proteins. For example, troponin T, an important regulatory protein found on the thin filament, exhibits a shift from the fast T3 isoform, to the slow T1 isoform, in mouse soleus muscle following high fat feeding, with no associated change in myosin heavy chain isoform [1]. These results suggest that DIO may cause fast fibres to express slow isoforms of sarcomeric proteins in postural muscles of mixed fibre-type.
The purpose of this study was to assess the force-calcium and force-velocity relationships of skinned fast and slow fibres of vastus intermedius, a mixed fibre-type postural muscle [2], in chow-fed rats and a rat model of DIO. It was hypothesized that fast fibres from DIO rats would exhibit characteristics associated with a slower fibre phenotype, including increased calcium sensitivity and lower shortening velocities.

METHODS

Individually housed male Sprague-Dawley rats, aged 10-12 weeks, were randomized to undergo diet induced obesity (DIO) where they were fed a high fat, high sugar diet (n = 6) or a standard chow diet (n = 6) for 12 weeks. The caloric content of DIO diets was 40% fat and 45% sucrose, compared to chow diets which consisted of 12% fat and 0% sucrose. Both vastus intermedius muscles were collected from each rat. Similar to the mouse soleus, the fibre type distribution of rat vastus intermedius is approximately 50% type I and 50% type IIa fibres [2]. Muscles were chemically skinned in a glycerol-rigor solution for 2 weeks. Two fast and two slow fibres per animal were then isolated and mounted in a model 802B skinned fibre test system (Aurora Scientific) at 2.4 µm sarcomere length for testing. Preliminary fibre type assessment was made using a strontium sensitivity test [3]. The force-pCa relationship was assessed from pCa 7.2 to pCa 4.2. The force-velocity relationship was assessed by measuring the shortening velocity during isotonic contractions. Maximal shortening velocity (V_{max}) was assessed by a slack test protocol. Statistical differences were determined using Student's t-test or a two-way factorial ANOVA and Newman-Keuls post-hoc analysis as appropriate, $\alpha = 0.05$.

RESULTS

Dual-energy X-ray absorptiometry scans revealed DIO rats had significantly higher body mass, fat mass, and greater percent body fat than chow fed rats (all $p<0.05$), while lean mass was not significantly different between groups. DIO did not affect the force per cross-sectional area (CSA) of skinned fibres (Table 1). Fast DIO fibres had significantly lower maximum shortening velocities when compared to fast chow fibres ($p<0.05$; Table 1). No such differences were observed in slow fibres. Independent of fibre type, DIO fibres had significantly higher calcium sensitivity than chow fibres ($p<0.01$, Table 1). While the Hill coefficient of the force pCa relationship was different between fast and slow chow fibres, no differences were seen in DIO fibres ($p<0.05$; Table 1).

Table 1: Contractile properties of skinned fibres

Parameter	Fast Chow	Fast DIO	Slow Chow	Slow DIO
Force/CSA (mN/mm^2)	136±16	124±13	172±24	180±17
V_{max} (L_o/s)	2.03±0.44	0.67±0.07*	0.92±0.17*	0.97±0.37*
Ca50	6.21±0.03	6.25±0.01†	6.37±0.02‡	6.43±0.02†‡
Hill Coefficient	4.60±0.53	3.92±0.35	3.21±0.19*	4.38±0.39

Values are means ±SEM. * - $p<0.05$ vs. fast chow. † - DIO > chow; $p<0.01$. ‡ - fast < slow; $p<0.01$.

DISCUSSION AND CONCLUSIONS

Consistent with a fast to slow phenotype transition, V_{max} was lower in fast DIO fibres. However, DIO influenced the force-calcium relationship of both fast and slow fibres. Therefore, adaptations are not limited to fast fibres, but rather influence contractility on a larger scale. Whether this influence is global or localized to postural muscles remains to be determined. The specific isoforms of contractile proteins expressed in single fibres should be assessed following DIO.

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