Characterization of Changes in Eccentric Work *In Vivo* during a Chronic Exposure of Stretch-Shortening Cycles: Age Effects

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INTRODUCTION

Musculo-skeletal injury in aged workers has been identified as an important research focus by The National Occupational Research Agenda [1]. However, the effect of age on skeletal muscle adaptation from repetitive mechanical loading has not been studied extensively. It is clear that susceptibility to contraction-induced injury increases with age [2]. The purpose of this research was to investigate if aging affects the ability of skeletal muscle to adapt to repetitive exposures of stretch-shortening cycles (SSCs). Skeletal muscle adaptation was assessed by characterizing changes in dynamic performance longitudinally during the chronic exposure period. We tested the specific hypothesis that young animals can adapt to repetitive mechanical loading of potentially injurious SSCs while older animals will not be able to adapt. Adaptation was defined by a maintenance or increase in eccentric (negative) work as a result of the repetitive exposures, while mal-adaptation was defined as a decrease in negative work as a result of the exposures.

METHODS

Male F344 x BN F1 rats (N = 11) were obtained from the National Institutes on Aging colony. Young adult (N=6, 330g ± 28 g SD, 12 weeks of age) and old (N= 5, 588g ± 32 g SD, 30 months) rats were housed in an AAALAC accredited animal quarters. The dorsiflexor muscles were tested on a custom-built rodent dynamometer. The dynamometer provides precise control over the muscle length and muscle force output parameters to be studied. Rats were anesthetized with 2% isoflurane gas and placed supine on the heated x-y positioning table of the rodent dynamometer, with an anesthetic mask placed over its nose and mouth. The knee was secured in flexion (at 90 deg) with a knee holder. The young and old age groups were exposed to 80 total SSCs. The SSCs were administered in 8 sets of 10 repetitions each with 2 minute intervals between each set. Within each set, there was a rest of 2 s between each SSC. For each repetition, the muscles were activated for 100 ms and the SSC was initiated with a movement velocity of 60 deg/s over the prescribed range of motion of 90 to 140 deg ankle angle. The dorsiflexor muscles were then deactivated 300 ms later. Total stimulation time per repetition was 2.06 s. The exposure protocol and performance tests were administered three times per week for a total of 14 exposures over a 4.5 week period. The dynamic force response was modeled by calculating the negative work from each SSC, and then mathematically characterizing the change in negative work within each set of 10 repetitions and between set using a power law: $T_t = f(t) = P_0 - \alpha \cdot t^{\beta}$

RESULTS AND DISCUSSION The ability to absorb negative work differed between age groups with subsequent exposures during the chronic exposure period (p = 0.011). Negative work increased in the young group for sets 1-8 during the chronic exposure period, but remained static in the old group (Fig 1a). Negative work was not different with age at the 1st exposure, but was statistically higher in the young group by the 7th exposure (p = 0.001) and the trend continued at the 14th exposure (p < 0.0001, Fig 1a). Model parameters (α and β) were quantified (Figs 1b and 1c) and the analytical model fit well to the experimental data for all sets throughout the exposure period (1st, 7th, and 14th exposures shown, Fig 1d).

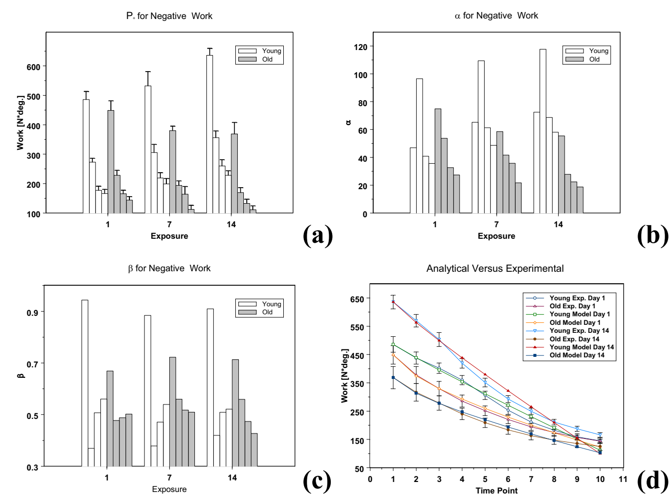

Figure 1: (a) The negative work of the old and young groups for sets 1-8 of the 1st, 7th, and 14th exposures. (b) Parameter (α) of the old and young groups for sets 1-8 of the 1st, 7th and 14th exposures. (c) Parameter (β) of the old and young groups for sets 1-8 of the 1st, 7th, and 14th exposures. (d) Analytical versus experimental response for 1st, 7th, and 14th exposures.

CONCLUSIONS

Age negatively affects the ability to adapt to repetitive exposures of SSCs as evidenced by a significant increase in negative work in the young group as compared with the old group. Also, there was a statistically greater decline in negative work during each exposure in the old group as compared with the young group. The power law accurately characterizes the changes in negative work within each session, and across sequential sessions, and quantifies the difference in dynamic response between age groups during the 4.5 week exposure.

REFERENCES

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