Motor unit discharge rate during submaximal isometric contractions in young and older adults following resistance exercise

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Introduction

In previous investigations, we have demonstrated that: 1) motor unit discharge rate during maximal voluntary effort is greater in young adults than in older persons, though motor unit discharge rate at 50% of maximal effort is similar in these two groups (Kamen et al., 1995), 2) motor unit discharge rates at submaximal forces declines as a result of resistance exercise training in young and older adults (Patten et al., 2000), and 3) maximal motor unit discharge rate frequently increases following exercise training (Patten et al., 2001). However, these investigations were conducted in small muscles of the hand. In a cross-sectional experimental design involving m. rectus femoris, we have determined that maximal motor unit discharge rate is greater in elderly individuals accustomed to many years of resistance exercise, than in physically active elders (Leong et al., 1999). The present study was conducted to determine whether young and older adults would exhibit differences in motor unit discharge rate at 50% MVC in a larger muscle, and whether submaximal discharge rate would change during exercise training.

Methods

Experiments were conducted in seven young (ages 18 – 29 years; \( \bar{x} = 21 \) yrs) and eight older adults (67 – 81 years; \( \bar{x} = 77 \) yrs). Informed consent was obtained in accord with procedures described in the Declaration of Helsinki (World Medical Organization, 7-12-1996).

Subjects attended the laboratory on each of four days. The Day 1 baseline measurement was followed by a re-test one week later (Day 8). Resistance exercise training immediately ensued and each subject was then re-tested after two and six weeks of training. The exercise training was conducted thrice weekly and included three maximal knee extensor contractions (100-degree knee angle) and three sets of 10 dynamic knee extensor contractions, using a load of 85% of 1-RM. No subject had participated in resistance exercise training within the last year.

On each of the four test days, subjects were seated and asked to perform 3-5 maximal isometric contractions of the non-dominant knee extensors at 100\(^\circ\) of knee extension. Motor unit recordings were then obtained from the vastus lateralis using a four-wire needle electrode while the subject performed 50% MVC knee extensor isometric contractions lasting 20 s. The resultant multi-channel muscle fiber signals were digitized (51.2 ksamples/s), bandpass filtered (1kHz – 10 kHz), and stored. Off-line, individual muscle fiber action potentials were identified using customized signal recognition software, and discharge rates subsequently computed at 50% MVC using the mean of the fastest six consecutive interfireing intervals (IFI’s) as previously reported (Kamen et al., 1999).

Results and Discussion

As expected, increases in isometric knee extensor torque were observed in both subject groups. Torque scores were 28% higher in the young than in the older subjects (p < 0.05). Following exercise training, the young and older groups increased maximal knee extensor torque by 29% and 36%, respectively (p<0.05).
Across the four test days, 410 motor unit action potential trains were identified trains in the young and older adults. On each of the four assessment days, motor unit firing rate at 50% of maximal force was 27% slower in the older adults than in the young adults (14.0 vs 17.8 impulses/s; Figure 1), and the difference in discharge rate between the two groups was statistically significant ($p < .001$). As demonstrated in Figure 1, there was little change in motor unit discharge rate at 50% MVC over the four days for either subject group ($p > .05$). Moreover, there was scarcely any difference in discharge rate between the two subject groups over the exercise training interval as demonstrated by a non-significant group x day interaction.

![Vastus Lateralis Motor Unit Discharge Rates at 50% MVC](image)

Figure 1. Motor unit discharge rates obtained from m. vastus lateralis were significantly higher in young subjects than in older individuals at each of the four test points. No change in discharge rate was observed across the six weeks of exercise training.

The significant difference in motor unit discharge rates between the two groups at the submaximal 50% MVC level contrasts with our earlier results suggesting that motor unit discharge rate differed little between young and older adults at 50% MVC. However, these earlier findings were obtained in small muscles (first dorsal interosseous and abductor digiti minimi), although data demonstrating the lack of different between older well-trained individuals and older fit subjects were recorded in rectus femoris. It may be that the larger vastus lateralis presents a more sensitive measure of age-related differences in motor unit discharge rate, although the research literature is somewhat equivocal regarding motor unit discharge rate differences among young and older adults (Roos et al., 1999; Roos et al., 1999).

The failure to observe a change in motor unit discharge rate at 50% MVC following exercise training is also somewhat different than the results obtained from maximal isometric contractions, in which an initial rapid increase in maximal discharge rate is frequently accompanied by either a decline in discharge rate with exercise training or stable motor unit discharge rates (Kamen et al., 1998; Patten and others, 2001) with little change in total muscle activation (Knight et al., 2001 in press). Again, it appears that the greatest changes in motor unit discharge rate following exercise-induced adaptations are observed at 100% of maximal effort.
We conclude that lower motor unit discharge rates during submaximal effort seem to be observed more readily in the larger vastus lateralis than in smaller muscle groups. Unlike the initial increase in discharge rate observed at 100% of maximal voluntary effort, resistance training seems to have little influence on submaximal motor unit discharge rate at 50% of maximal effort.

References


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