Improvements in the Rate of Force Development-Scaling Factor Following a High Speed-Low Resistance Cycling Exercise Program

Maria Bellumori, MS and Christopher A. Knight, PhD

University of Delaware, Newark, DE, USA
email: mariab@udel.edu

INTRODUCTION

Physical quickness is a movement quality of widespread interest in sport, aging, falls, pathology and rehabilitation. Under the instructions to produce isometric muscular force pulses most rapidly and across a range of submaximal amplitudes, there is a positive linear relationship between the peak force (PF) of a pulse and the corresponding rate of force development (RFD) [1]. The slope of this relationship, termed the rate of force development–scaling factor (RFD-SF), quantifies the extent to which RFD scales with the amplitude of the contraction. Studies involving maximal power training have shown improvements of this measure in both young and older adults [3].

It has been suggested that maximal force production does not always correlate with functional ability [2] and high resistance exercise may not be advisable for all elderly and patient populations. Therefore, the first aim of this study was to determine whether a six week exercise program that uses high speed-low resistance stationary cycling would improve the quickness of isometric muscular force production in knee extensors (KE) as well as functional measures in older adults. Assuming that improved quickness would be observed, a second aim was to determine if training in the legs (KE) would transfer to increases in quickness in the arms (elbow extensors - EE) indicating a central adaptation.

METHODS

Participants visited the laboratory for baseline testing. Assessments included quickness testing (to determine RFD-SF) and functional measures including the Timed Up & Go (TUG) test, 6 meter walk test, and nine-hole peg test. Participants included 6 older adults (mean (SD) age = 73(7) years, height = 165.4(11.4) cm, mass = 77.3(14.9) kg) recruited from a local senior center.

To obtain the RFD-SF, participants were instructed to produce each isometric pulse as quickly as possible and then relax instantly. Participants completed five trials consisting of five brief pulses to each of four approximate amplitudes (20, 40, 60, 80 %MVC). Visual feedback of force was provided as a vertical bar graph, on a computer screen placed at eye level. Isometric pulses were performed in the KE and EE while seated in a custom chair.

Similar to the methods used by others [1] the PF-RFD relationship was computed from the sets of rapid isometric contractions (pulses) performed across a full range of amplitudes. Linear regression parameters were calculated for each subject and the slope (RFD-SF) was the main dependent measure of interest. RFD was computed as the first derivative of force pulses across over-lapping .1s intervals.

After baseline testing, participants completed a six week recumbent cycling program supervised by the experimenter (2 days/week = 12 sessions). During the first session, preferred pedaling cadence (PPC) was determined. Fast cycling was initially defined as 20% faster than the PPC. Exercise sessions began with a 5 minute warm up at the PPC. Then participants completed 10 bouts of fast cycling lasting 20 seconds each. There was a 60 second active recovery period, at PPC, between fast bouts. Sessions concluded with a 5 minute cool down at the PPC. As participants progressed through training, their fast cycling cadence was increased in sensible, individually determined increments.

Upon training completion, participants were assessed in the same baseline parameters to test for improvements. They were tested again four weeks after training cessation to determine if such improvements were retained.
RESULTS AND DISCUSSION

After six weeks of cycling, RFD-SF improved in all cases except one. One individual’s RFD-SF decreased slightly in right EE. There were no differences between the left and right limbs within each individual pre- and post-exercise (p>.1). There were differences between individuals indicating that some had greater muscular quickness than others. Greater RFD-SF is associated with higher quality function of the nervous system [1,3].

**Figure 1:** Means of RFD-SF before and after cycling intervention. Error bars (SE) indicate between-subjects variability in RFD-SF values. There were significant improvements in RFD-SF in both EE (left and right sides) and KE (left and right sides) with exercise (p<.05). Means decreased 4 weeks post-exercise but were not significantly different than post-exercise.

Despite high variability between subjects, this high speed-low resistance cycling program elicited visible improvements in the ability to produce rapid isometric muscle contractions across a full range of forces. Such contractions are especially relevant to fall prevention in the elderly and those with neural impairments as well as activities of daily living including typing, catching an object before it falls, and crossing the street quickly. In conjunction, there were improvements in the TUG and 6 meter walk test which are both standardized measures of walking ability. Along with improved walking speed, most individuals reported increased confidence in walking and ability to take larger steps. That there were improvements in the RFD-SF in EE as well as the 9 hole peg test (a standardized tool to assess hand dexterity) suggests that training one set of muscles may induce adaptations in the central nervous system. Further analysis of these measures in a control group will elucidate the magnitude of these effects.

**Figure 2:** There were significant improvements in all functional measures (means presented) pre-post exercise (p<.05) and there were no changes 4 weeks following post-exercise testing (p>.05).

It is anticipated that the RFD-SF is a measure with high potential to inform rehabilitation researchers and human movement scientists about the quality of movement initiation and the quickness of force production. The RFD-SF measure is appealing because it can be used to quantify the quality of quick force production across the full range of amplitudes, and the resulting units (s-1) make it mathematically independent of strength and size of the muscle group of interest. This latter feature facilitates comparisons between individuals and between muscle groups with respect to the underlying neuromuscular determinants of quickness [1].

Interestingly, RFD-SF trended back toward baseline four weeks post-exercise (p>.05) while functional measures remained relatively constant. Retention of functional improvements may be suggestive of enhanced self-efficacy in these tasks. In addition, decreases in RFD-SF highlight the importance of remaining active to provide the stimulation necessary to maintain neuromuscular function.

REFERENCES