AGE AND FATIGUE EFFECTS ON LOWER EXTREMITY JOINT TORQUE DEVELOPMENT

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INTRODUCTION

Muscle strength decreases with age [Ditor & Hicks 2000], a phenomenon that is prominent in the lower extremities [Whipple et al. 1987]. This affects joint torque development, which likely plays a role in balance recovery [Robinovitch et al. 2002; Mackey & Robinovitch 2006]. Therefore age-related reductions in torque development may increase fall risk among older adults. Localized muscle fatigue induced by exercise or other activities of daily living may compound this risk by further reducing strength output. Therefore the purpose of this study was to investigate the combined effects of age and fatigue on joint torque development characteristics. We hypothesized that a) older adults, compared to young, would have reduced torque development performance; and b) localized muscle fatigue would have a more debilitating impact on older adults, compared to young.

METHODS

Participants. Thirteen young (YA: mean age 26 ± 2.5 years) and twelve older (OA: mean age 71 ± 2.8 years) male adults participated in this study after providing written informed consent as approved by the institution's human subjects committee.

Tasks. Each participant performed isometric contractions of ankle plantarflexors or knee extensors to produce joint torque equal to 40% of his maximum voluntary contraction torque on a Cybex 6000 dynamometer (CSMI, Norwood, MA). One task was performed before and after a fatiguing exercise. Fatigue was induced by performing isokinetic contractions on the dynamometer using the ankle plantarflexors and knee extensors at rates of 30 and 60 degrees per second, respectively. Ankle and knee testing sessions were done separately within a single laboratory visit.

Measurements. During each 15-second trial, torque data was sampled at a rate of 2 kHz using a personal computer running LabVIEW (National Instruments, Austin, TX) through a 16-bit A/D data acquisition card (National Instruments).

Analysis. Data was processed using MATLAB (Mathworks, Natick, MA). Torque development was quantified using onset time (t_{onset}): the time from stimulus to torque development; settling time (t_{settle}): the first time at which torque remained within 5% of the target level for 1 second; and rate of torque development (S): the slope of a line fit between t_{onset} and the time at which torque reached 70.7% of the target value. Statistical analyses were done with SPSS 14.0 (SPSS Inc., Chicago, IL). Independent samples t-tests were used to detect age effects among pre-fatigue trials. Paired samples t-tests were used to assess fatigue effects within each age group. Age-related differences in fatigue effect were detected by calculating the difference (Δ) in each

variable between pre- and post-fatigue, and performing independent samples t-tests on Δ with age as the independent variable.

RESULTS AND DISCUSSION

Results are summarized in **Table 1**. OA, compared to YA, exhibited longer settling times (ankle) and slower torque development (ankle and knee). Post-fatigue trials, compared to pre-fatigue, were characterized by slower rates of torque development in YA only (ankle and knee). In the ankle joint, this resulted in a significant age-related difference in fatigue effect: rate of torque development decreased with fatigue in YA, but not in OA. These results suggest that aging reduces the ability to quickly generate a submaximal torque about the knee and ankle joints. The age effects observed have implications for balance recovery if age-related declines progressed to a level at which joint torque was not produced quickly enough to restore balance, increasing fall risk. These results also suggest fatigue-related performance declines in YA, but no fatigue-related performance changes in OA. This result does not support our hypothesis. This may be partially explained by preferential atrophy of type II fibers and motor unit remodeling [Merletti et al. 2002], whose combined effects may result in increased fatigue resistance among OA.

SUMMARY/CONCLUSIONS

Joint torque development performance appears to decline with age; however, localized muscle fatigue does not further diminish performance in OA. This suggests that muscle fatigue does not compound the existing fall risk among OA; however, aging alone may present a significant fall risk if torque development performance falls below the level needed for balance recovery.

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Table 1: Means ± SD of primary outcome variables. Superscripts denote significant age^{A} and fatigue^{F} effects ($p<0.05$).

	Ankle				Knee			
	Pre-Fatigue		Post-Fatigue		Pre-Fatigue		Post-Fatigue	
	YA	OA	YA	OA	YA	OA	YA	OA
t_{onset} (ms)	332±162	580±369	288±206	571±399	280±127	328±171	258±62	305±173
t_{settle} (ms)	2196±1106	4614±2899^{A}	3089±2532	6088±3584	2022±1357	3577±2408	1885±866	3561±2408
S (Nm/s)	96.3±51.5	52.0±28.3^{A}	44.9±21.9^{F}	40.8±47.7	119.9±67.0	51.4±23.7^{A}	70.4±45.1^{F}	39.5±28.0