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Ankle variability is amplified in older adults due to lower EMG power from 30–60 Hz

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ABSTRACT

The purpose of this study was to determine the neuromuscular mechanisms of the involved muscles that contribute to the greater positional variability at the ankle joint in older adults compared with young adults. Eleven young adults (25.6 ± 4.9 years) and nine older adults (76.9 ± 5.9 years) were asked to accurately match and maintain a horizontal target line with 5° dorsiflexion of their ankle for 20 s. The loads were 5 and 15% of the one repetition maximum load (1 RM). The visual gain was kept constant at 1° for all trials. Positional variability was quantified as the standard deviation (*SD*) of the detrended position signal. The neural activation of the tibialis anterior and soleus muscles was quantified as the normalized EMG amplitude, power spectrum density (PSD; EMG oscillations) and coactivation of the two muscles. As expected, positional variability was greater in older adults (older: 0.11 ± 0.06° vs. young: 0.04 ± 0.02°; $p = .003$). The only significant neural difference occurred for the PSD of the tibialis anterior muscle, where young adults exhibited significantly greater power than older adults from 30–60 Hz. The amplified positional variability of ankle joint in older adults was associated with lower power from 30–60 Hz oscillations in the tibialis anterior muscle ($r^2 = .3$, $p = .01$). These results provide novel evidence that older adults exhibit greater positional variability with the ankle joint relative to young adults likely due to their inability to activate the tibialis anterior muscle from 30–60 Hz.

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1. Introduction

The functional capability of older adults is influenced by their amplified motor output variability. For example, a more variable gait is associated with falls in older adults (Guimaraes & Isaacs, 1980). In the experimental lab setting, this amplified motor output variability in older adults compared with young adults is evident from higher force variability when they exert forces against an immovable resistance (force transducer) (Burnett, Laidlaw, & Enoka, 2000; Galganski, Fuglevand, & Enoka, 1993; Keen, Yue, & Enoka, 1994; Laidlaw, Bilodeau, & Enoka, 2000; Semmler, Steege, Kornatz, & Enoka, 2000) and from greater positional variability when they lift and lower loads (Burnett et al., 2000; Christou & Carlton, 2002; Graves, Kornatz, & Enoka, 2000). This age-associated amplification in motor output variability in both tasks is amplified at very low intensity levels (Christou & Enoka, 2010).

Numerous functional movements require the stabilization of a light load in a constant position. For example, maintaining the position of the accelerator while driving is a positional task with the ankle joint. It is not clear in the literature whether older adults exhibit greater positional variability with the ankle when they attempt to maintain the position of a light load. It is important to determine whether the positional control of the ankle joint is similar for young and older adults because it is heavily involved in many functional activities including walking (Begg & Sparrow, 2006; Kemoun, Thoumie, Boisson, & Guieu, 2002), negotiating stairs (Alimusaj, Fradet, Braatz, Gerner, & Wolf, 2009; Vanicek, Strike, McNaughton, & Polman, 2010; Wilken, Sinitski, & Bagg, 2011), postural control (Kouzaki & Shinohara, 2010) and driving (Behr et al., 2010; Webber & Porter, 2010). We expect that older adults would exhibit greater variability with the ankle joint during a position-holding task at low loads for the following reasons: (1) Previous findings clearly demonstrate that older adults exhibit greater motor output variability than young adults during constant force contractions with the ankle joint (Kouzaki & Shinohara, 2010; Tracy, 2007). (2) Older adults exhibit greater motor output variability than young adults during position-holding task with the index finger (Tracy, Mehoudar, & Ortega, 2007). (3) Age-associated differences in motor output variability occur primarily at low-intensity contractions (Christou & Enoka, 2010).

Numerous mechanisms have been proposed as the cause of the age-associated amplification in motor output variability. For example, older adults exhibit greater motor unit discharge rate variability than young adults, which is associated with amplified force variability during constant force tasks (Enoka et al., 2003). There is also evidence that older adults exhibit different neural activation of the antagonistic muscles than young adults, which contributes to their amplified motor output variability during goal-directed isometric (Christou, Poston, Enoka, & Enoka, 2007) and anisometric (Christou & Enoka, 2010) tasks. Finally, recent evidence suggests that older adults do not modulate the agonist muscle activity from 13–60 Hz as much as young adults. Their impaired ability to modulate the agonist muscle from 13–60 Hz was related to an exacerbation of force variability with greater visual gain during constant force tasks (Kennedy & Christou, 2011). There is evidence that EMG oscillations from 13–60 Hz reflect the modulation of the motor neuron pool by higher centers (Brown, 2000; Mima & Hallett, 1999; Neto, Baweja, & Christou, 2010; Omlor, Patino, Hepp-Reymond, & Kristeva, 2007).

In summary, previous studies suggest that positional control of the ankle may be impaired in older adults due to altered activation of the agonist muscles (Kennedy & Christou, 2011). Altered activation of the involved muscles is examined with quantifying a coactivation index (Winter, 1990) or by quantifying the modulation of muscle activity (Neto & Christou, 2010). The purpose of this study, therefore, was to determine the neuromuscular mechanisms of the involved muscles that contribute to the greater positional variability at the ankle joint in older adults compared with young adults. We hypothesized that older adults will exhibit impaired positional control with the ankle joint compared with young adults when trying to maintain light loads due to altered modulation of the antagonistic muscles. Part of the data has been presented in abstract form (Kwon, Baweja, Glover, & Christou, 2010).