Age-related differences in temporal scaling of postural EMG activity

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ABSTRACT. Electromyographical (EMG) burst onset times for postural muscles were compared in young and elderly male and female subjects performing a forceful abrupt pull with the right arm against a load cell apparatus while standing. EMG activity was collected via surface electrodes from the posterior deltoid, and right and left hamstring and quadriceps muscles. Pulls were performed at varying force levels from 100% to approximately 50% of a maximum effort. Regression equations were developed for each postural muscle for each group, using force production values as the independent variable, and postural muscle onset latencies (relative to deltoid onset) as the dependent variable. Regression slopes for postural muscles of elderly subjects ranged from 0.59 to 0.33, while slopes for the young subjects ranged from 0.72 to 0.63. Less elevated slopes for the elderly may indicate a reduced ability to temporally scale postural muscle onset latencies to variations in the force of the upper-limb task; a reduction in this ability may constitute a possible contributing factor to instability in the elderly.


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It is well documented that elderly individuals generally demonstrate less stability in stance under static postural conditions than younger adults, and demonstrate slower corrective postural adjustments to unexpected challenges to equilibrium (1-4). The implications of age-related losses in stability have been shown to carry over to voluntary movements by Morse, Tylko, and Dixon (5) who reported that a large proportion of falls in the elderly occur while engaged in voluntary movement. Thus, understanding the relationship between balance, posture, and intentional movement in the elderly is a particularly important concern in light of the risk to well-being imposed by movement related falls.

Intentional movement of the upper-limbs can be sufficiently forceful to disrupt equilibrium during stance. To counteract this threat to equilibrium, younger, healthy subjects generally initiate a postural response prior to the initiation of a forceful upper-limb movement in a direction opposite the force vector of the upper-limb task (6-9). However, if this anticipatory postural response (APR) is impaired or not well coordinated with the upper-limb movement, a decrease in postural stability is likely to occur. Chronological age has been proposed as a variable which is related to a loss in the integrity of the APR, thus a decrease in stability in voluntary movement conditions (1, 10). Research supporting this contention has primarily employed either tasks in which subjects were to initiate movement as rapidly as possible in response to a stimulus (reaction time tasks), or self-paced movements at maximal speed. For example, it has been shown

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that older adults take longer to initiate a postural response under reaction time conditions for such tasks as a unilateral leg raise (11), or a handle push or pull (12). It has also been reported that, in comparison to younger subjects, postural responses of elderly subjects occurred closer in time to initiation of a rapid arm raise for both reaction time movements and self-paced movements performed as rapidly as possible (13). In some instances, older adults activate inappropriate postural muscles onset sequences to counteract the force vector arising from a destabilizing reaction time task (14).

While reaction time tasks and maximal speed self-paced movements have been valuable paradigms to illustrate that latency of the postural response changes in advanced age, these tasks are not particularly well suited for illuminating how the postural response is adapted to maintain equilibrium when the voluntary task is other than a maximal effort task. For example, when the upper-limb task requires production of a specific submaximal level of force, it is not clear whether onset of the postural response is appropriately timed to preserve stability in the elderly. Evidence exists that young adults performing forceful upper-limb tasks are able to vary (scale) onset of the postural response to graded changes in the force of the upper-limb task (9, 15-17). That is, postural activity is timed such that onset occurs a greater period of time in advance of an upper-limb task generating a large degree of force, than one generating a lesser degree of force. Because it is largely unknown whether the ability to temporally scale the postural response to variations in upper-limb force is maintained in advanced age, it is possible that deficits in temporal scaling ability could contribute to postural stability problems associated with advanced age. Improperly timed onset of a postural response may result in either an under-response, or an over-response to the challenge to equilibrium from an intentional upper-limb task, possibly leading to a fall. Thus, the major objective of this study was to determine whether temporal organization of postural activity differed between young and elderly subjects who performed a forceful upper-limb task across a range of maximal and submaximal forces. This was accomplished by comparing postural muscle electromyographical (EMG) onset latencies in elderly and young adults.

EMG activity was collected from postural muscles of elderly and young males and females performing abrupt pulls of various forces with the right arm while standing. It was expected that in younger subjects, a substantial relationship would exist between onset latencies of postural muscles (relative to onset of the pulling task prime mover, posterior deltoid) and variations in pulling force, suggesting the ability to temporally scale onset latencies relative to pulling force. Evidence of temporal scaling was expected to occur whether a postural muscle was active prior to (anticipatory in nature) or after onset of activity in the pulling task prime mover. For the elderly, it was expected that the magnitude of this relationship would be lower, suggesting a diminished ability to temporally scale onset of postural EMG activity with variations in pulling force.

**MATERIALS AND METHODS**

**Subjects**

We studied 24 right-handed adults. Four groups (N=6 per group) were formed: an elderly female group (M=72.5 years, age range 68 to 76); a young female group (M=24.8 years, age range 20 to 26); an elderly male group (M=75.8 years, age range 72 to 80); and a young male group (M=24.4 years, age range 21 to 27). Elderly subjects were recruited from a retiree exercise program for former university faculty. A medical history screening was performed on all individuals prior to inclusion in the study to ensure that none had a history of falls, and were free of pathologies known to impair postural response function. None of the subjects had a history of falls in the last 5 years (with the exception of 5 subjects who fell while participating in sporting activities, such as basketball and snow skiing). Two elderly female subjects and one young female subject reported slipping on ice in the 5 years prior to testing. In addition, all subjects reported freedom from impaired musculoskeletal or neurological function secondary to clinically diagnosed pathologies that might affect the organization of postural activity (e.g., stroke, cerebellar deficit, Parkinson’s disease, syncope, vestibular dysfunction or dizziness, severe orthopedic prob-