Grasp Force Modulation During Bimanual Tasks in Young and Elderly Adults

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Introduction

Bimanual tasks involving static force production with one hand and transient manipulative force with the other hand are performed at least 30% of the day (Clark et al., 1990). It is known that hand grasp and coordination decline with aging, and are associated with the need for additional assistance in self-care activities (Falconer et al., 1991). However, little is known about bimanual force interactions when the two hands generate different force levels at different times. The purpose of this preliminary investigation was to characterize force production in young and elderly adults during bimanual grasp tasks involving different force levels at initiation and termination.

Methods

Subjects:
Twelve young [mean age 22y (range 22-27y)] and twelve elderly [mean age 79y (range 75-87 y)] adults participated in this study. All were right-handed, in good physical health, and living independently in the community. Subjects with a history of neurologic, orthopedic, or arthritic conditions affecting hand function were excluded from the study.

Paradigm:
Subjects were seated at a table with the elbow at approximately 90 deg, the forearm resting on the table and in neutral position, and the wrist in approximately 30 deg extension. Grasp force was initiated and terminated in response to an auditory tone occurring at 4 s intervals, as follows: Tone 1-static grasp onset, Tone 2-transient grasp onset, Tone 3-transient grasp termination, Tone 4-static grasp termination.

Force levels were self-selected and included a firm force, between 40-70% maximum voluntary contraction (MVC), and a light force, below 20% MVC. Practice trials were provided as needed for each subject. All trials were counterbalanced for force level and hand. Trials included:

• LL Light static grasp with light transient grasp
• LF Light static grasp with firm transient grasp
• FF Firm static grasp with firm transient grasp
• FL Firm static grasp with light transient grasp

Data were digitized at 100 Hz and analyzed offline. Force onset and termination points were determined using a custom-designed LabVIEW (National Instruments) software program.

Results

Typical Force Records:
Firm Static with Firm Transient Grasp

• In general, young and elderly subjects produced large static hand force levels initially, declining between 20-30% to a more stable level.

• At transient hand force onset and termination, decreases in static hand force were observed for all subjects. This decrease was most pronounced at transient grasp termination and was greater in the elderly group.

• Following transient hand onset, both young and elderly subjects tended to decline in static force magnitude, with a greater force decline found when the static hand produced firm force.

• A greater decrease was shown in both age groups following transient hand termination.

• Both young and elderly adults showed a decrement in static hand grasp force at the time of transient force onset and termination produced by the other hand. Older adults exhibited a greater decrease in force at the time of transient grasp termination, especially when the nondominant hand produced static force. This may reflect neural cross-talk, with coupling of static to transient force modulation, as has been demonstrated in bilateral movement studies (Cattaert et al., 1999), and/or age-related deficits in attentional processing.

• These findings suggest that, in contrast to young adults, older adults may demonstrate an impaired ability to maintain independent force production and modulation in the presence of asynchronous force production in the contralateral hand. This impaired ability to produce independent grasp with each hand during bilateral tasks may play a significant role in decreased hand function seen in older populations.

Summary & Conclusions

Static Hand Peak Force Values

• Both young and elderly subjects produced similar static and transient forces in tasks requiring light force (LL, LF). Within-group variability (ISE) was similar in both age groups regardless of which hand (dominant, nondominant) produced static force.

• When the static hand produced firm forces, significant age-related decreases in static hand force were observed (* p<0.05, ** p<0.01, *** p<0.001).

• There were no significant within-group differences for either young or elderly subjects in light or firm static force between the dominant and nondominant hands.

• When the transient hand relaxed, decreases in static hand force (see B in force records) were consistently observed in both age groups and across all tasks, with greater decreases observed in elderly subjects.

• This effect was greatest in tasks where the nondominant hand produced static forces (* p<0.05, ** p<0.01, *** p<0.001).

• Declines in static force levels were consistently greater following transient hand termination as compared to onset in both age groups and across all tasks.

• All subjects showed a 7-15% decrease in static force at the time of transient force onset, as measured from the time of transient hand onset to transient hand peak force (see A in force records).

• This decrease was greater in elderly subjects across all tasks but was most notable with firm transient force production (LF, FF) when the nondominant hand produced static force (* p<0.05, ** p<0.01).

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References


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