Upper Limb Proprioceptive Acuity in the Elderly: The Effects of Physical Activity and Hand Preference

D. Adamo, C. Waechter, S.H. Brown
Motor Control Laboratory, Division of Kinesiology, University of Michigan

Introduction

Proprioceptive feedback arising from muscle, joint, and cutaneous receptors is critical for the control of coordinated limb movement, postural stability, and the learning and adaptation of goal-directed functional activity. Age-related declines in the utilization of upper limb proprioceptive ability have received little attention although existing studies suggest that the awareness of body position in the absence of vision is impaired in older individuals (Ferrell et al., 1992).

With aging, it has been demonstrated that physical activity influences muscle and cognitive functions but its impact on movement related sensory-motor feedback in the upper limb is not known. This is surprising given the importance of sensory feedback in the performance of skilled movement which, in turn, impacts functional independence. Furthermore, it is unclear if motor asymmetries such as those associated with hand dominance are retained by similar differences in proprioceptive function.

Recently, we showed that the ability to utilize somatosensory feedback for upper limb position and hand force matching tasks declines with age (Adamo et al., 2003, under review; Adamo et al., 2005). Such errors appear to be dependent upon the need for interhemispheric transfer and/or memory-based retrieval of proprioceptive information. Preliminary evidence from this laboratory has also shown that proprioceptive matching may be correlated with physical activity levels. The purpose of this study was to determine whether physical activity level, hand preference and task difficulty affects wrist position and grasp force matching abilities in older individuals.

Methods

Subjects:

- 5 young (Y; mean age 22.7 years
- 10 active elderly (AE; mean age 75 yrs, caloric expenditure > 2500 kcal/week
- 10 sedentary elderly (SE; mean age 75 yrs, caloric expenditure < 2500 kcal/week
- Cognitive status: MMSE score above 27
- Physical activity: Community Health Activities Model Program (CHAMPS)

Position Matching:

Subjects performed upper limb matching tasks in the absence of vision. All tasks involved active matching of a 40° degree passive wrist extension movement. Subjects were seated with both arms supported by an instrumental manipulandum which pivoted beneath the axis of arm joint rotation in the horizontal plane. Wrist position was measured by potentiometers connected to the axis of wrist joint rotation on each apparatus and recorded at 100Hz.

Force Matching:

Subjects produced a 20% maximum voluntary contraction (MVC) reference force level using visual feedback and maintained the force for 2s. The visual feedback disappeared and subjects reproduced the force with the same or opposite hand. Force was measured by strain gauges stabilized by cylindrical grasp devices and recorded at 100Hz.

Schematic of Matching Tasks:

In the bilateral (IR) and Contralateral RemembereRED (CR) conditions the reference position or force level was matched with the same (ipsilateral) or opposite (contralateral) hand. In the Contralateral Concurrent (CC) condition, the reference position or force level was maintained during matching with the opposite hand. Both the right and left hands were used to provide a reference position or force. The three matching tasks required retrieval of a proprioceptive memory (IR; CR) and/or interhemispheric transfer of proprioceptive information (CC; CR).

Results

PHYSICAL ACTIVITY PROFILES

- Active Elderly: • participates in volunteer and church activities, 2-6 hrs/week • pursues hobbies such as crocheting, woodworking • works on a computer, 2-3 hrs/week • walks only in pursuit of daily tasks, 4 hrs/week • minimal to no sedentary activity
- Sedentary Elderly: • pursues hobbies such as crocheting, • performs light house work, < 2 hrs/week • walks only in pursuit of daily tasks, 4 hrs/week • minimal to no sedentary activity

Elderly showed greater position matching error than young subjects across all conditions (p < 0.01). However, errors were greater in the young compared to active elderly group. In all groups, errors increased as task difficulty increased.

EFFECTS OF HANDEDNESS ON POSITION MATCHING

In the active and sedentary elderly groups, accuracy was greater when matching occurred with the left hand, particularly in the contralateral conditions (p < 0.05). While errors increased with task difficulty for the right hand, task effects were minimal when matching with the left hand. No differences were evident between hands in the young subjects.

EFFECTS OF HANDEDNESS ON FORCE MATCHING

In young and active elderly groups, there was an increase in error with an increase in task difficulty when matching with the right hand. Left hand matching was more accurate and less influenced by an increase in task difficulty. Right-left differences were most evident in the CR condition (p < 0.05).

Position and Force Matching Profiles

- Young: 20º in IR and CR conditions, 40º in CC condition
- Active Elderly: 20º in IR and CR conditions, 40º in CC condition
- Sedentary Elderly: 20º in IR and CR conditions, 40º in CC condition
- Force profiles illustrating force and a force’s time for CC left matching in young, active and sedentary elderly subjects. Higher and average force time duration (right). Both elderly groups showed significantly longer and more irregular force time courses compared to young (p < 0.01) but there were no differences between the two elderly groups.

Conclusions

- For both limb position and hand force tasks, active and sedentary elderly subjects demonstrated greater errors and took longer to perform matching tasks than young subjects.
- During position matching, error was less in the active compared to the sedentary elderly group while, during force matching, no clear differences related to physical activity were observed.
- Matching performance was better for the non-dominant hand performed either position or force matching, particularly during tasks which required interhemispheric transfer of proprioceptive information and/or reliance on a proprioceptively generated internal model of position or force.
- The results of the study suggest that non-specific physical activity may enhance the utilization of limb position feedback to a greater extent than force feedback. Furthermore, it is suggested that the non-dominant hand/hemisphere system may be specialized for upper limb tasks involving monitoring static grasp forces and limb position, which, with age, become increasingly asymmetric and task-specific.

References


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