Contralateral activity in a homologous hand muscle during voluntary contractions is greater in old adults

MINORU SHINOHARA, KEVIN G. KEENAN, AND ROGER M. ENOKA
Department of Kinesiology and Applied Physiology, University of Colorado at Boulder, Boulder, Colorado 80309-0354

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Shinohara, Minoru, Kevin G. Keenan, and Roger M. Enoka. Contralateral activity in a homologous hand muscle during voluntary contractions is greater in old adults. J Appl Physiol 94: 966–974, 2003. First published November 1, 2002; 10.1152/japplphysiol.00836.2002.—This study compared the amount of contralateral activity produced in a homologous muscle by young (18–32 yr) and old (66–80 yr) adults when they performed unilateral isometric and anisometric contractions with a hand muscle. The subjects were not aware that the focus of the study was the contralateral activity. The tasks involved the performance of brief isometric contractions to six target forces, slowly lifting and lowering six inertial loads, and completing a set of 10 repetitions with a heavy load. The unintended force exerted by the contralateral muscle during the isometric contractions increased with target force, but the average force was greater for the old adults (means ± SD: 12.6 ± 15.3%) compared with the young adults (6.91 ± 11.1%). The contralateral activity also increased with load during the anisometric contractions, and the average contralateral force was greater for the old subjects (5.28 ± 6.29%) compared with the young subjects (2.10 ± 3.19%). Furthermore, the average contralateral force for both groups of subjects was greater during the eccentric contractions (4.17 ± 5.24%) compared with the concentric contractions (3.20 ± 5.20%). The rate of change in contralateral activity during the fatigue task also differed between the two groups of subjects. The results indicate that old adults have a reduced ability to suppress unintended contralateral activity during the performance of goal-directed, unilateral tasks.

The decline in motor performance that accompanies healthy aging is attributable to a variety of physiological mechanisms, including adaptations that occur within the nervous system. The functional consequences of these adaptations include such effects as a decrease in the fine motor skills of the hand, a slowing of rapid arm movements, an alteration in the distribution of joint torques and powers in the leg during stepping down and walking, a reduced ability to detect joint displacement, and a decline in the capacity to accommodate disturbances of posture (7, 18, 24, 31, 42, 45, 49). These changes in performance must involve a reorganization of muscle activation, such as reductions in motor unit activity and alterations in the distribution of activity among the involved muscles. For example, older adults frequently exhibit heightened levels of antagonist muscle coactivation during the performance of goal-directed movements (4, 25, 41). This study examined another pattern of muscle activation that could contribute to differences in motor performance between young and old adults: activation of homologous muscles in the contralateral limb during the performance of a unilateral task.

Contractions at moderate-to-high forces are frequently accompanied by the activation of other ipsilateral and contralateral muscles (1, 2, 8, 52). When the intensity of the contralateral activity is sufficient to produce a movement, which can occur in children and in some pathological conditions, the behavior is referred to as a mirror movement (1, 12, 33). However, electromyographic activity can be observed in contralateral muscles in most healthy adults during unilateral contractions that require a substantial effort (5, 9, 14, 52). Although the unintended activity is sometimes described as contralateral irradiation, which can imply the spreading of excitation within the central nervous system, the neural mechanism underlying the contralateral activity may involve a reduction in transcallosal inhibition (1, 13, 15, 30, 46).

The purpose of the study was to compare the amount of contralateral activity produced by young and old adults when they performed unilateral isometric and anisometric contractions with a hand muscle. The contralateral activity was greater for the old adults, which indicates that they had a reduced ability to prevent unintended activity during the performance of unilateral goal-directed tasks. Furthermore, contralateral activity was less for both groups of subjects during anisometric contractions compared with isometric contractions. Some of these results have been presented previously in abstract form (23).

METHODS

Experiments were performed on the left and right hands of 10 young (5 women, 5 men; means ± SD 24.1 ± 5.3 yr; range...
18–32 yr) and 10 old (5 women, 5 men; 72.5 ± 4.9 yr; range 66–80 yr) subjects with no known neuromuscular disorders. All subjects were right-hand dominant, as assessed by the Edinburgh Handedness Inventory (35), performed no more than minimal levels of physical activity on a regular basis and did not participate in activities that involved skilled activities with either hand (e.g., play a musical instrument, engage in racket sports, or ride a bicycle). The Institutional Review Board at the University of Colorado approved the experimental procedures, and all subjects gave informed consent before participation in the study.

Experimental Setup

The experiments were performed on the first dorsal interosseus muscle of both hands. The subject was seated and facing a video display monitor that was located 1.5 m away at eye level for the subject. All subjects affirmed that they could see the video display clearly. Both arms were abducted ~0.5 rad, and the elbows were flexed to a right angle, with the hands and forearms prone and resting on separate manipulanda. Each hand was placed in a prone position with the index finger horizontal and with the other three fingers flexed around a semicircular grip (28). The thumb was braced in a horizontal position by a restraint that maintained the angle between the first and second metacarpals at ~1.57 rad. Each index finger was placed in an individualized splint that kept it extended. The hand and forearm of each arm were restrained with vacuum foam pads that were molded to the shape and location of the limb.

Mechanical Recording

Subjects performed isometric contractions by pushing against a force transducer and completed anisometric contractions by lifting and lowering an inertial load.

Isometric contractions. The test hand was placed in the manipulandum so that the index finger was in a neutral position. A force transducer (Sensotec model 13, Columbus, OH) attached to the splint detected the abduction force at the proximal interphalangeal joint of the index finger. The sensitivity of the transducer differed for high-force [≥40% maximum voluntary contraction (MVC) force; 0.045 V/N; linear range 0–220 N] and low-force tasks (≤10% MVC force; 0.45 V/N; 0–9.81 N).

Anisometric contractions. A low-friction, linear variable differential transducer (LVDT; novotechnik, Stuttgart, Germany) was used to detect the abduction-adduction displacement of the index finger about the first metacarpophalangeal joint during the position-tracking task. The LVDT was mounted on an extended delryn platform, and it was placed perpendicular to the proximal interphalangeal joint when the index finger was placed in the neutral position. The LVDT was attached to a waxed string that was directed over a pulley and connected to the finger splint at the proximal interphalangeal joint. The LVDT was calibrated for each subject and session over the range of motion. The loads lifted by the subject were suspended from the LVDT.

Contralateral activity. The subjects were not aware that the focus of the study was the contralateral activity. For each unilateral task (both isometric and anisometric contractions), the splinted index finger of the contralateral hand was secured to the force transducer with a Velcro strap. The force exerted by the index finger of the contralateral hand in the abduction direction due to an isometric contraction of the first dorsal interosseous muscle was measured with a low-sensitivity transducer (0.06 V/N; 0–220 N).

Electrical Recording

The surface electromyogram (EMG) of the first dorsal interosseus muscle was recorded with bipolar electrodes (4-mm diameter, silver-silver chloride; ~25 mm apart center-to-center) that were secured to the skin overlying the muscle on each hand. One electrode was placed over the belly of the muscle, and the other electrode was attached to the skin over the base of the proximal phalanx of the index finger. A common electrode (4-mm diameter, silver-silver chloride) was placed on the styloid process of the ulna on the dorsal surface of the hand. The surface EMG signals were amplified (500–1,000 times), band-pass filtered (20–800 Hz), and displayed on an oscilloscope.

Experimental Procedures

Each of the 20 subjects was asked to perform three tasks with the index finger of each hand: 1) assessment of isometric strength with a MVC in the abduction direction; 2) brief isometric contractions at several target forces; and 3) anisometric contractions with several inertial loads. The order of testing the two hands was varied randomly across subjects. After each hand had completed these three tasks, the last hand tested performed a set of fatiguing contractions. For each task, the subject was instructed to focus on the hand being tested and to relax the rest of the body. One of the investigators checked the force and EMG recording for the contralateral hand before the beginning of each contraction, and the subject was again instructed to relax the body if any activity was detected.

MVC. The MVC task involved a gradual increase in the abduction force exerted by the index finger from baseline to maximum in 3–4 s and then sustained at maximum for 1–2 s. The index finger force was displayed on the monitor. The timing of the task was based on a verbal count given at 1-s intervals, with vigorous encouragement from the investigators when the force began to plateau. Each subject performed three MVC trials, with subsequent trials performed if the difference in peak force between two MVCs was >5%. The trial with the highest peak force was chosen for analysis.

Isometric contractions. The target forces, which were presented to the subject randomly, were set at 2.5, 10, 40, 60, and 80% MVC force. On the basis of feedback provided on the monitor, the subject gradually increased the abduction force to the target force and sustained it at this value for either 20 s (target forces < 50% MVC force) or 10 s (target forces > 50% MVC force). The sensitivity of the force display was set relative to the target force so that the distance from the baseline to the target force was kept constant across trials. The subject performed either two (target forces < 50% MVC force) or one (target forces > 50% MVC force) trial at each target force.

Anisometric contractions. The maximum load that each subject could lift once using the first dorsal interosseus muscle [one-repetition maximum (1-RM load)] was estimated from the MVC force of the subject. On the basis of a previously determined relation between 1-RM load and MVC force (4, 29), 1-RM load was set at 51% MVC force for young subjects and at 36% MVC for old subjects. Loads corresponding to 2.5, 10, 40, 60, 80, and 100% of the 1-RM load were attached in random order to the line and connected to the splint at the level of the proximal interphalangeal joint. Each load was first lifted (6 s) and then lowered (6 s) by moving the index finger through a 0.35-rad range of motion.

Fatiguing contractions. The last hand to perform the preceding set of three contractions then completed a sequence of 10 anisometric contractions with an 80% 1-RM load. Because
of the random order in which the hands were tested, the fatiguing contractions were performed by 10 left and 10 right hands in these right-hand dominant subjects. The time between each contraction was 8 s. The subjects were not informed that the task involved 10 contractions until completion of the ninth contraction. To assess the level of fatigue caused by the 10 contractions, an MVC was performed immediately after the tenth anisometric contraction was completed.

Data Analysis

All data collected during the experiments were recorded and stored in digital format (Sony PC 116 digital audio tape recorder; bandwidth direct current to 5 kHz) and analyzed off-line by use of the Spike2 data analysis system (Cambridge Electronic Design, Cambridge, UK) with custom-designed software. The index finger force and position signals were sampled at 256 Hz, and the EMG data were sampled at 1,024 Hz.

Dependent variables. The dependent variables for the iso-
metric and anisometric tasks performed by each hand were the peak force and the average of the full-wave rectified EMG (AEMG) for a 0.5-s window centered at the peak force during the trial. The dependent variable for the fatiguing contractions was the AEMG during a 0.5-s window centered in the middle of the concentric and eccentric contractions (lifting and lowering the load). When each hand was being tested, the force and AEMG in the contralateral hand were also recorded. The dependent variables for the contralateral hand were the peak force and the associated AEMG for a 0.5-s window. The force and AEMG were expressed both in absolute values and normalized to the respective maximum values. For the conditions that involved two trials (<50% MVC force and 1-RM load), the trial with the largest value was used in the analysis.

Statistical analysis. The dependent variables for the MVC and 1-RM tasks were compared with a two-factor ANOVA (2 age groups × 2 hands) with repeated measures on hand. The dependent variables for the isometric contractions were compared with a three-factor ANOVA (2 age groups × 2 hands × 6 target forces) with repeated measures on hand and target force. The dependent variables for the anisometric contractions were compared with a four-factor ANOVA (2 age groups × 2 hands × 6 loads × 2 contraction types) with repeated measures on hand, load, and contraction type. The dependent variables for the fatiguing contractions were compared with a three-factor ANOVA (2 age groups × 2 hands × 10 repetitions) with repeated measures on hand and repetition. MVC force before and after the fatiguing contractions was compared with a two-factor ANOVA (2 age groups × 2 testing times) with repeated measures on testing time. An α level of 0.05 was chosen for all initial statistical comparisons, with post hoc comparisons (Newman-Keuls) performed when necessary. Unless stated otherwise, the data are presented as means ± SD in the text and table and as means ± SE in the figures.

RESULTS

The results report the amount of activity in the contralateral homologous muscle when young and old subjects performed various isometric and anisometric contractions with the first dorsal interosseus muscle of each hand separately. The data are expressed relative to the maximum values achieved during an MVC by each hand.

The two groups of subjects preferred to use the right hand for most activities of daily living, as indicated by similar values for the laterality quotient (35) for the young (0.69 ± 0.15) and old subjects (0.78 ± 0.23). Similarly, the MVC forces were not different for either the two groups of subjects (P = 0.24) or the two hands (P = 0.35; Table 1), and the associated AEMG was not different (P = 0.08 for the two groups and P = 0.11 for the two hands). The 1-RM load, however, was greater for the young subjects (P < 0.01).

Isometric Contractions

When subjects performed isometric contractions to the six target forces, there was invariably concurrent activity in the contralateral first dorsal interosseous muscle (Fig. 1). The force and AEMG in the contralateral hand increased with target force for both groups of subjects (Fig. 2) and was significantly greater for the old subjects (force = 12.6 ± 5.3%; AEMG = 19.3 ± 17.9%; P < 0.05) compared with the young subjects (force = 6.91 ± 11.1%; AEMG = 8.43 ± 10.3%). The relative amount of contralateral activity exhibited by the two groups of subjects, however, varied with the hand performing the task. When the test hand was the right hand, the average contralateral force and AEMG were significantly greater for the old subjects (force = 13.8 ± 7.1%; AEMG = 21.6 ± 20.9%) compared with young subjects (force = 4.7 ± 10.3%; AEMG = 6.2 ± 9.0%; Fig. 3). When the test hand was the left hand, there was no difference in the contralateral force and EMG recorded in the right hand. There was no difference in the amount of contralateral activity between the two hands in either group of subjects (Fig. 3).

Anisometric Contractions

When subjects performed anisometric contractions with the six loads, the first dorsal interosseus muscle in the contralateral hand was typically activated (Fig. 1). As with the isometric contractions, the force and AEMG in the contralateral hand increased with load, and there was a significant main effect for age (Fig. 4, A and B), with the values for the old subjects (force = 5.28 ± 6.29%, AEMG = 11.8 ± 10.9%) being greater than those for the young subjects (force = 2.10 ± 3.19%, AEMG = 4.52 ± 5.04%). Furthermore, there was a significant main effect for contraction type (Fig. 4).

Table 1. Strength and AEMG values during the MVC and 1-RM tasks

<table>
<thead>
<tr>
<th></th>
<th>MVC force, N</th>
<th>MVC AEMG, mV</th>
<th>1-RM load, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old subjects</td>
<td>25.7 ± 6.8</td>
<td>0.495 ± 0.179</td>
<td>0.943 ± 0.249</td>
</tr>
<tr>
<td>Right hand</td>
<td>25.8 ± 7.7</td>
<td>0.573 ± 0.201</td>
<td>0.948 ± 0.284</td>
</tr>
<tr>
<td>Left hand</td>
<td>25.5 ± 6.1</td>
<td>0.417 ± 0.118</td>
<td>0.935 ± 0.224</td>
</tr>
<tr>
<td>Young subjects</td>
<td>28.6 ± 5.7</td>
<td>0.637 ± 0.228</td>
<td>1.495 ± 0.298</td>
</tr>
<tr>
<td>Right hand</td>
<td>29.9 ± 6.5</td>
<td>0.639 ± 0.239</td>
<td>1.556 ± 0.340</td>
</tr>
<tr>
<td>Left hand</td>
<td>27.6 ± 4.8</td>
<td>0.634 ± 0.228</td>
<td>1.434 ± 0.252</td>
</tr>
</tbody>
</table>

Values are group means ± SD; n = 10 subjects (5 men, 5 women) per group. AEMG, average of full-wave rectified electromyogram values; MVC, maximal voluntary contraction; 1-RM, one-repetition maximum.
4, C and D) in that the contralateral force (P < 0.01) and AEMG (P < 0.05) were greater during the eccentric contractions (4.17 ± 5.24 and 8.68 ± 0.97%, respectively) compared with the concentric contractions (3.20 ± 5.20 and 7.65 ± 9.40%, respectively). There was also a significant interaction between contraction type and load, with the difference between the two contraction types being significant for most loads ≥ 40% 1-RM load (Fig. 4, C and D). Nonetheless, the contralateral activity was less (P < 0.01) during the anisometric contractions (3.7 ± 5.2%) compared with the isometric contractions (9.7 ± 13.7%). When the data were collapsed across hands and age groups at target forces > 50% MVC force, as suggested by the post hoc analysis, the contralateral force was 15.5 ± 16.6% for the isometric contractions and 4.95 ± 6.17% for the anisometric contractions. Moreover, there were no effects of hand on the contralateral force and AEMG, in contrast with the isometric contractions (Fig. 3).

Fatiguing Contractions

The amount and rate of change in the activity of the contralateral first dorsal interosseous during the set of 10 anisometric contractions differed for young and old adults. The strategy used by the old subjects was to maintain a constant level of force (11.9 ± 10.2%) and AEMG (21.2 ± 11.4%) in the contralateral hand across the 10 contractions during the anisometric contractions, whereas the young subjects increased both the contralateral force (2.34 ± 3.27 to 20.4 ± 15.2%) and AEMG (4.67 ± 5.10 to 29.6 ± 21.0%; Fig. 5). This difference in activity in the contralateral hand occurred despite comparable and constant levels of AEMG in the test hand of the young (concentric = 81.4 ± 31.5%; eccentric = 41.0 ± 18.2%) and old subjects (concentric = 71.0 ± 15.6%; eccentric = 42.2 ± 12.5%). The contralateral force and AEMG were significantly greater for the old subjects only during the first three contractions. MVC force declined by 22–25% at the conclusion of the 10 repetitions for both groups of subjects: MVC force for young subjects was reduced from 28.5 ± 5.8 to 21.4 ± 6.6 N, and that for old subjects decreased from 24.9 ± 7.5 to 19.4 ± 5.6 N.

DISCUSSION

The main findings were that the contralateral activity in the homologous hand muscle exhibited by all subjects when performing voluntary contractions with the first dorsal interosseous muscle was greater for old subjects compared with young subjects, for isometric contractions compared with anisometric contractions, and for eccentric contractions compared with concentric contractions. Furthermore, the rate of change in contralateral activity during a set of fatiguing contractions differed for the two age groups.

A previous study on contralateral activity in the first dorsal interosseus muscle of young adults reported similar results to those obtained in the present study (52). They found contralateral forces of 7.6 ± 5.5% in the dominant hand and 8.2 ± 7.9% in the nondominant hand during MVCs performed with the first dorsal interosseus muscle by young adults, which compared with 6.91 ± 11.1% in the present study. Furthermore, they indicated that although all subjects demonstrated contralateral activity, there was substantial variability between subjects, as indicated by the large standard deviations. Neither group of young subjects, those tested by Zijdewind and Kernell (52) and those examined in the present study, exhibited a difference in the
amount of contralateral activity between the two hands. In both studies, there was an increase in the contralateral activity with target force, except at the highest forces (80 and 100% MVC force). Similarly, the contralateral activity increased during a fatiguing contraction for the young subjects in both studies: despite differences in the two protocols, Zijdewind and Kernell (52), for example, found no association between the bilateral deficit and the amount of contralateral activity in young subjects, which suggests that the inability to provide maximum activation to homologous muscles in two hands was not related to the unintended activity during a unilateral contraction. Furthermore, the strength gains experienced by older adults because of cross education, probably because of the spread of activation at subcortical and spinal levels, are similar to those achieved by young adults (38, 47, 50).

Difference Due to Age

Several phenomena, such as crossed reflexes, the bilateral deficit, and cross education, underscore the possibility that physical activity performed by one side of the body can evoke acute adjustments and chronic adaptations on the other side of the body (6, 18, 20, 21, 26, 48, 50). A key question in identifying the mechanism responsible for the greater contralateral activity exhibited by older adults is whether the activity results from the spread of excitation or the removal of inhibition within the central nervous system. Despite descriptions of contralateral activity as irradiation, most evidence suggests that the removal of inhibition is the dominant mechanism. Zijdewind and Kernell (52), for example, found no association between the bilateral deficit and the amount of contralateral activity in young subjects, which suggests that the inability to provide maximum activation to homologous muscles in two hands was not related to the unintended activity during a unilateral contraction. Furthermore, the strength gains experienced by older adults because of cross education, probably because of the spread of activation at subcortical and spinal levels, are similar to those achieved by young adults (38, 47, 50).

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Fig. 2. Maximum contralateral force (A) and average rectified EMG (AEMG; B) for the young and old subjects during isometric contractions performed with the first dorsal interosseus muscle of the other hand to 6 different target forces. Data shown are group means ± SE.

Fig. 3. Maximum contralateral force (A) and AEMG (B) for the young and old subjects during unilateral isometric contractions performed with the first dorsal interosseus muscle of the left and right hands. Solid bars indicate the force and EMG recorded in the right hand when the task was performed by the left hand. Conversely, open bars indicate the contralateral activity in the left hand when the task was performed by the right hand. Data shown are group means ± SE. *P < 0.05 compared with the same hand of the young subjects.
In contrast, electrophysiological measurements suggest a cortical origin for the unintended contralateral activity. For example, when the cutaneousmuscular reflex was evoked in the hand of individuals who exhibited contralateral activity in first dorsal interosseus, the transcortical component of the reflex was enhanced when a unilateral task was being performed (33). This result suggests a heightened level of excitation among the corticospinal neurons contralateral to the unintended activity, which indicates that the unintended activity arose from the contralateral cortex and not the ipsilateral cortex. Although unilateral hand movements are associated with bilateral activation of the premotor cortex and supplementary motor area (16, 34, 44, 51) with significant differences due to age (32), the absence of unintended contralateral activity appears to be the result of transcallosal inhibition (1, 13, 15, 30, 33, 40). Furthermore, a flat cross-correlation histogram derived from the interference EMGs of the first dorsal interossei in both hands during a unilateral task indicated that the contralateral activity was not due to common input to the two motor neuron pools (33). Rather, the potential evoked in a muscle in response to transcranial magnetic stimulation of one motor cortex was reduced in amplitude when the stimulus was preceded (7–15 ms) by a conditioning stimulus delivered to the other motor cortex (33). The reduction in the evoked response is consistent with an inhibitory effect mediated by the transcallosal pathway (1, 13). Children did not exhibit a decrease in the conditioned response, because of an immature transcallosal pathway, but did display more frequent episodes of unintended contralateral activity (33).

Imaging studies indicate that the structure of the corpus callosum changes across the life span. The mid-sagittal cross-sectional area of the anterior half of the corpus callosum, for example, was larger in magnetic resonance images of professional musicians who began training in music before 7 yr of age (39). The anterior fibers contribute significantly to bimanual coordination.
Conversely, there is a small but consistent decrease in the size of the corpus callosum after middle age, which is presumed to underlie the decline in sensorimotor function that involves the transfer of information between the two hemispheres (3, 37). Although these findings suggest that the greater contralateral activity exhibited by the older subjects during unilateral tasks may be a functional consequence of such changes in the corpus callosum, there are other marked changes that influence connectivity in the cerebral cortex of older adults. For example, there is evidence of reduced cortical excitability (10) and depressed intracortical inhibition (36) during unilateral tasks performed by older adults. As a consequence, the greater unintended contralateral activity observed in older adults may reflect a change in the balance between interhemispheric excitation and inhibition within the cerebral cortex (16).

Isometric and Anisometric Contractions

The appearance of unintended contralateral activity is often described as being task dependent (1, 8, 17, 52). For example, Mayston et al. (33) reported no such activity when adults performed opposition movements with the thumb and fingers, whereas many subjects experienced contralateral activity with index finger abduction, which they described as a less familiar task. Subjects also performed abduction of the index finger in the present study; however, the amplitude of the contralateral activity was less during anisometric contractions compared with isometric contractions but greater for eccentric contractions compared with concentric contractions. These effects were observed in both groups of subjects, despite the older adults typically experiencing the greatest difficulty with slow lengthening contractions (4, 27–29). Furthermore, the relative AEMG (percentage of the MVC maximum) was consistently a greater percentage of the normalized force (percentage of the MVC force) during the isometric and anisometric contractions for both groups of subjects, which suggests coactivation of the antagonist muscle (second palmar interosseus) during these tasks by both young and old subjects.

In contrast to the qualitative similarity in the relative amplitudes of the contralateral activity for the two types of contractions performed by both groups of subjects, there was a marked difference for the set of fatiguing contractions. Consistent with the results of Zijdewind and Kernell (52), the young subjects increased the contralateral activity progressively during the task beginning with a value that was comparable to a single repetition with the 80% 1-RM load. The old subjects, however, sustained a constant level of contralateral activity during the 10 repetitions and began with a value that was greater than observed during a single repetition of the task. Although unintended contralateral activity is typically considered to depend on the intensity of the unilateral contraction (5, 9, 14, 52), the behavior exhibited by the old adults indicates contralateral activity that was not graded with the effort of the unilateral task.

Functional Implications

The decline in manual dexterity experienced by older adults (42) undoubtedly results from changes in muscle activation during the performance of fine motor skills (4, 27, 28, 41). It is tempting to speculate that the results from the present study provide further evidence of altered patterns of muscle activation exhibited by older adults. The functional significance of these findings, however, must be tempered by consideration of the extent to which the results from this constrained protocol can be generalized to the activities of daily living. If it is indeed possible to generalize, then it appears that older adults exhibit greater amounts of unintended contralateral activity during both brief and fatiguing contractions, that the amount of contralateral activity is greater for both young and old adults when the test hand performs isometric contractions.
and that the amplitude of the contralateral activity varies with the intensity of the contraction performed by the test hand.

One example of contralateral activity consistent with these conditions is the unintentional discharge of a handgun. For example, if a person performs a high-intensity isometric contraction with the left hand while holding a handgun in the right hand, the unintended contralateral activity can cause the gun to discharge. Such incidents are experienced occasionally by law-enforcement officers when they attempt to apprehend a struggling individual with one hand while holding a gun in the other hand. As a consequence, many firearms instructors propose weapon-handling strategies that minimize the unintended placement of the index finger on the trigger of the gun (22). This example introduces another factor not considered in the present study, however: the amount of contralateral activity probably depends on the level of physiological arousal experienced by the individual. Although the functional significance of unintended contralateral activity presumably varies along a continuum from a null effect to a substantial effect, it seems premature to assign a level of significance to the present findings. Nonetheless, the results indicate that activation of a hand muscle by the nervous system during the performance of unilateral tasks differs for young and old adults and for isometric and anisometric contractions.

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