

Original articles

**THE INFLUENCE OF AGE-RELATED CHANGES IN
TACTILE SENSIBILITY AND MUSCULAR STRENGTH
ON HAND FUNCTION IN OLDER ADULT FEMALES**

Short running title: Aging and hand function

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ABSTRACT

Background: Aging affects the human hand function. For example, a decline in manual dexterity often accompanies old age. This decline corresponds to age-related changes in muscle and/or tactile functions. This study investigated whether age-related changes in muscular strength and tactile sensibility are related to the hand function.

Methods: The subjects consisted of sixty-four older adult females. The hand function was assessed using Perdue pegboard test. The handgrip strength was measured using a handgrip dynamometer. Tactile-pressure threshold was evaluated using Semmes-Weinstein monofilaments. These tests were performed on the dominant hand. All data items were compared among the four age groups (65–69 years; n=17, 70–74 years; n=16, 75–79 years; n=15, 80–85 years; n=16).

Results: The scores on Perdue pegboard test showed significant differences among the four age groups and they decreased with age. The tactile-pressure threshold was augmented with increasing age, whereas handgrip strength did not differ among the four age groups. A significant relationship was observed between the Perdue pegboard test score and tactile-pressure threshold ($r = -0.61$), but not the handgrip strength ($r = 0.18$).

Conclusions: These results suggested that the manual dexterity in the hand function

was attenuated with increasing age. We considered that this attenuating effect was associated with a decline in tactile sensibility rather than a change in the muscular strength of the hand.

Key words: Aging, manual dexterity, tactile-pressure threshold, handgrip strength

Introduction

The changes in motor function that accompany aging include a marked decline in strength and muscle mass, leading to impairments in mobility and the activities of daily living (ADL). Regarding the decrease in lower extremity strength, a prior study reported that the decline in lower extremity strength begins after the fifth decade of life¹. This decline in strength associated with aging impairs individual's ability to respond quickly and forcefully to prevent a fall after a postural disturbance, thus leading to increased falling by elderly individuals²⁻⁵. These previous results suggested a close relationship between motor function and lower extremity strength.

Aging also affects human manual function, as reflected by the skillful use of the fingers in grasping, lifting, and manipulating objects. A previous study reported that a 15% loss in strength per decade occurs in individuals of 50 to 70 years old³. This age-related change in strength corresponds to a decrease in skeletal muscle mass⁶. On the other hand, human hands show excellent sensory function as well as motor function. For example, the human hand can discriminate the texture, shape, and temperature of surfaces by touching them with the fingers. However, this sensory perception gradually weakens with aging, resulting in worsening performance in ADL such as fastening buttons, tying shoelaces, writing a note, etc.⁷ due to age-related changes in muscular strength and sensation in the hand as described above. However,

regarding hand motor function, which requires highly skilled motor control, age-related changes in hand sensation may be more important as a determinant of the decrease in manual function than muscular strength in the elderly, in contrast to lower limb motor function, which involves an element of gross motor function. This study, therefore, investigated whether age-related changes in muscular strength and tactile sensibility are related to manual function in older adults.

Materials and Methods

Subjects

Sixty-four adult females aged 65-84 years (mean age: 74.4 ± 5.8 years) participated in this study. All the subjects professed to be in good health on a standard medical examination questionnaire, and lived independently in the community. None of the subjects had the common diseases, which are known to influence neuromuscular function of the hand, such as carpal tunnel syndrome, osteoarthritis of hand joints, diabetic polyneuropathy, or cervical spondylosis-related cervical radiculopathy. However, three subjects indicated diet-controlled diabetes. Another thirty-nine subjects were on regular medication for cardiovascular problems and/or osteoarthritis of knee joints and/or low back pain. The remaining twenty-two elderly individuals did not take regular medication. Moreover, prior to the study, we administered the

Mini-Mental State Examination, and all subjects passed (borderline passing score of 25). To clarify the age-related changes in hand function, the participants were divided into four age groups (65–69 years; n=17, 70–74 years; n=16, 75–79 years; n=15, and 80–85 years; n=16). Each subject was informed in advance of the purpose of the study and of the procedures involved, and their consent was obtained. This study was performed in accordance with the Declaration of Helsinki and approved by the Institutional Ethical Committee of Nagasaki University.

Measurements

Manual function was assessed using the Perdue pegboard test (Lafayette Instrument, Lafayette, IN). This standardized, reliable⁸ means of evaluating hand and finger function involves retrieving small metal pegs (length: 25mm, diameter: 3mm) from a cup and placing them in a line of holes. The number of pegs placed in the holes within 30 sec was recorded. Handgrip strength was measured using a digital handgrip dynamometer (TKK5401, Takei Kiki Kogyo, Japan). These tests were repeated twice with the dominant hand, and the maximum value was determined. The tactile-pressure threshold on the distal palmar pad of the index finger was evaluated using Semmes-Weinstein monofilaments (North Coast Medical, Morgan Hill, CA). We used 20 kinds of filaments ranging in weight from 0.004 to 447 grams. For each filament,

the aesthesiometer pressure in grams was converted to $\log_{10}0.1\text{mg}$, yielding a scale composed of intervals of approximately equal intensity between filaments. The subjects were tested with their eyes closed after receiving clear instructions. The target area was marked on the volar side of the distal phalanx of the dominant index finger. Each filament was pushed into the target area until it bent about 90° for about a second. The threshold was recorded as the smallest filament diameter that could be perceived in at least 80% of its applications (5 trials).

Statistical analysis

Differences due to age were examined using one-way analysis of variance (ANOVA). If a significant F value was found for a main effect, Tukey's post hoc test was performed to detect significant differences in mean values among the four age groups. Furthermore, Pearson's correlation was performed to determine the relationships between the pegboard test score and handgrip strength or tactile-pressure threshold. The level of statistical significance was defined as $P < 0.05$. The data are expressed as the mean \pm standard error.

Results

Age-related Changes in the Purdue Pegboard Score, Handgrip Strength, and Tactile-pressure Threshold

The pegboard test scores for the four age groups (65–69 years, 70–74 years, 75–79 years, 80–85 years) were 15.9 ± 1.7 , 14.0 ± 2.6 , 12.8 ± 2.7 , and 12.6 ± 1.5 , respectively.

This age-related change in the functional test scores (pegs placement) showed significant differences among the four age groups ($P < 0.01$; Figure 1A). However, handgrip strength did not differ among the four age groups (65–69 years; 22.1 ± 3.8 kg, 70–74 years; 20.6 ± 3.2 kg, 75–79 years; 20.8 ± 2.6 kg, 80–85 years; 19.7 ± 4.3 kg, $P = 0.29$; Figure 1B). In contrast to the results for handgrip strength, the tactile-pressure threshold increased with age (65–69 years; $2.8 \pm 0.3 \log_{10} 0.1\text{mg}$, 70–74 years; $3.0 \pm 0.4 \log_{10} 0.1\text{mg}$, 75–79 years; $3.1 \pm 0.3 \log_{10} 0.1\text{mg}$, 80–85 years; $3.2 \pm 0.3 \log_{10} 0.1\text{mg}$, $P < 0.01$; Figure 1C)

Relationships Between the Purdue Pegboard Score and the Tactile-pressure Threshold or Handgrip Strength

The Purdue pegboard test score showed no relationship with handgrip strength ($r = 0.18$, $P = 0.17$; Figure 2A) and a negative relationship with the tactile-pressure threshold ($r = -0.61$, $P < 0.01$; Figure 2B).

Discussion

The purpose of this study was to evaluate the age-related changes in manual function, tactile sensation, and muscular strength in older adult females and to identify the relationships between tactile sensation or muscular strength and manual function. Our major findings were that there was a significant decline in the Purdue pegboard test scores, which were used as an index of manual function, and that the tactile-pressure threshold showed higher values with increasing age, whereas handgrip strength showed no difference among the age groups. Furthermore, a negative correlation was observed between the pegboard score and tactile-pressure threshold, but no such relationship was found for handgrip strength. These results suggested that the worsening of manual function with age was closely associated with a decline in tactile sensibility rather than a change in muscular strength in the hand.

Ranganathan, et al.⁹ previously demonstrated the Purdue pegboard test scores in an elderly group (65–79 years old) to be significantly lower than those in a young group (20–35 years old), suggesting that manual function worsens with age. Similarly, our result for the pegboard test, which was performed by elderly subjects, also showed a worsening of hand function due to aging. These results indicated that the decline in manual function due to aging continues throughout old age.

The sensory function of the hand is also affected by aging. Thornbury et al.¹⁰

investigated tactile-pressure thresholds on the pad of the index finger in 55 individuals aged 19 to 88 years and found that the tactile-pressure threshold increased with age (correlation of $r = 0.56$). The present result also showed higher tactile-pressure thresholds with increasing age, indicating that the influence of aging on hand sensation as well as manual dexterity continues in old age. It has been reported that morphological changes in the peripheral receptors and central nervous system develop due to aging (decreases in the sensory receptors and brain weight)¹¹⁻¹⁴. These influences are considered to be involved in the augmentation of hand sensation thresholds (attenuation of sensation and sensitivity) in the elderly. Furthermore, a significant correlation was observed between the Purdue pegboard test scores and tactile-pressure thresholds in the present study. These results suggest that the control of manual function, which requires accuracy, is affected by the amount of sensory feedback information arising from skin sensory receptors.

Many previous studies have reported that handgrip strength decreases with age^{3,15,16}. However, our results showed handgrip strength to be only slightly affected by increasing age in older adult females. A possible explanation for the above inconsistency is that all of the subjects that participated in this study were independent with regard to their ability to perform ADL and lived in the same community. Thus, even though the ages of the individuals varied, the amount of ADL that they

performed would have been similar. The handgrip strength observed in this study might have reflected the amount of ADL performed by these individuals. In addition, the muscle mass in the hand is smaller than that of other muscles, especially in older adults. Therefore, the effect of muscle atrophy due to aging may be also small, and so differences in strength may not be detected easily. On the other hand, no clear relationship was observed between the Purdue pegboard test scores and handgrip strength in this study. Ranganathan, et al.¹⁷ previously found that nonspecific skill training of the hands by healthy old adults improved pegboard test scores, but not strength. Taken together, these findings suggest that handgrip strength does not always reflect manual function.

Currently, assessments of motor output such as muscular strength and control of voluntary movement are mostly used as indexes of hand function in physical fitness tests for the elderly. However, the present study suggested that a well-maintained tactile sensation is more important for the manipulation of the hand in the elderly than muscular strength. It is thus speculated that the management and improvement of hand functions involving hand sensation is necessary to effectively promote the health of elderly individuals.

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Figures

Figure 1. The age-related changes in pegboard test scores (A), handgrip strength (B), and tactile-pressure threshold (C). The data were compared among the four age groups (65–69 years: ■, 70–74 years: ■, 75–79 years: ▨, 80–85 years: □). * $P < 0.05$.

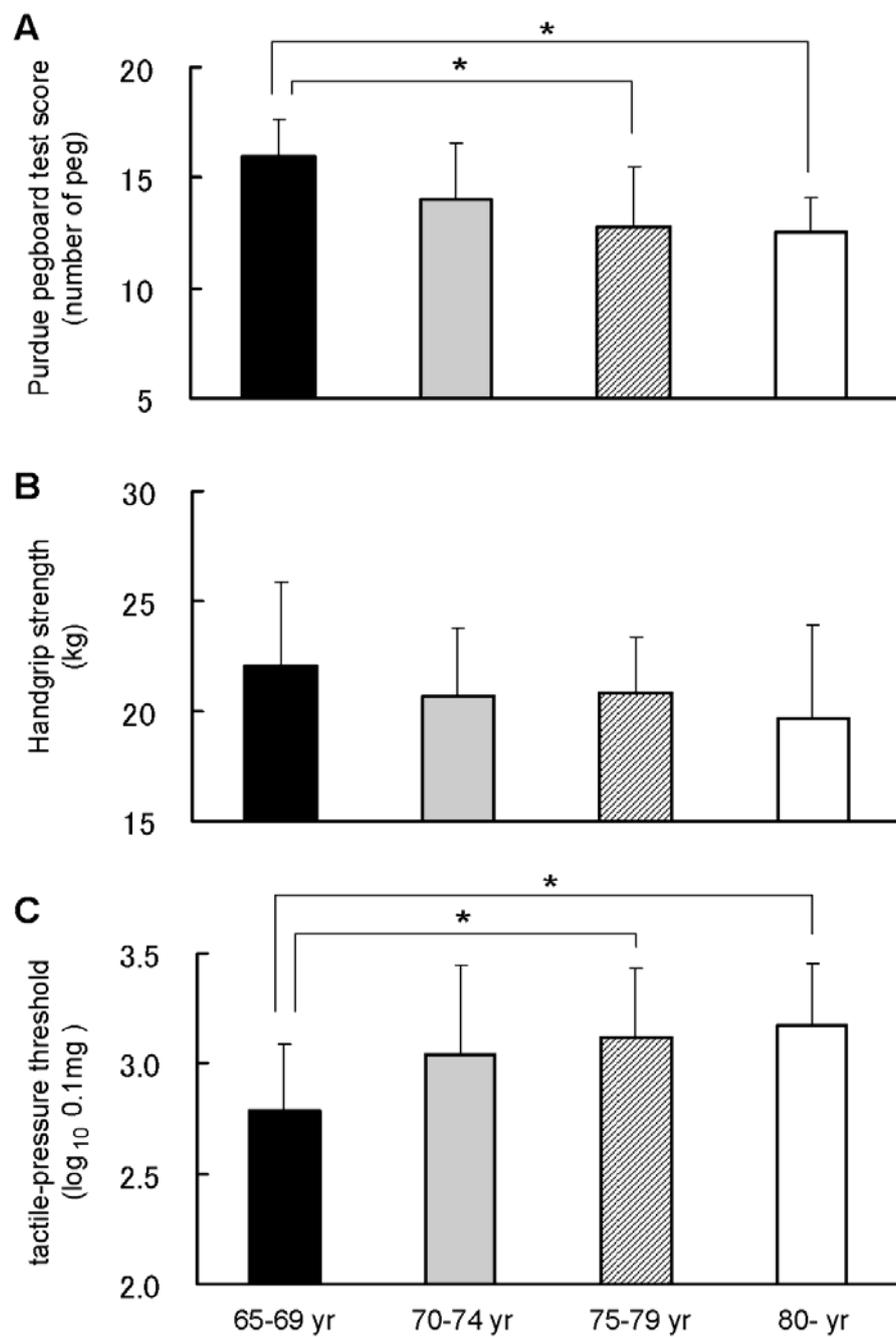


Figure 2. Associations between the Purdue pegboard score and handgrip strength (○) or tactile-pressure threshold (●). The linear regression lines shown in A and B are represented by $y=0.12x+11.32$ ($r=0.18$, $P=0.17$) and $y=-4.31x+26.90$ ($r=0.61$, $P<0.01$), respectively.

