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Finger Tap Reaction Time as an Independent Prognostic Factor for Functional Outcome in Older Adults

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Background: Decline in physical performance has been established as a risk factor for mortality and disability in older adults. Although previous studies have reported the age-related changes in finger-tapping ability, no study has been published describing the prognostic implications of finger tap reaction time among community-dwelling older adults. **Methods:** A total of 433 participants (227 men and 206 women) aged over 65 years were enrolled in the Korean Longitudinal Study on Health and Aging. According to the finger tap reaction time, participants were divided into 2 groups: a fast-reaction group and a slow-reaction group. We analyzed the interaction between delay in motor speed measured using the finger-tapping task and 5-year poor functional outcome, defined as short physical performance battery (SPPB) scores of 9 or less or mortality, during the follow-up period. **Results:** A significant increase in the risk of poor functional outcome was observed in the slow-reaction group, compared with in the fast-reaction group, even after covariate adjustment using multiple logistic regression analysis (odds ratio, 2.21; 95% confidence interval, 1.37–3.58). **Conclusion:** We conclude that delayed finger tap reaction time is an independent prognostic factor for poor functional outcome in older adults.

Key Words: Finger tapping, Physical activity, Aged, Cohort study, Prognosis

INTRODUCTION

Deterioration in physical performance is a prognostic factor for mortality and disability in older adults. In one study enrolling 4,182 older adults, functional decline as assessed by stride length and grip strength was related to an increased risk of mortality and disability in activities of daily living (ADLs), mobility, and upper-extremity function[1]. Grip strength has been shown to be a good marker for physical performance, and greater grip strength was associated with a better short physical performance battery (SPPB) score among community-dwelling older adults[2]. In another study from Japan, poor physical performance predicted an increase in falling events, which have been identified as one of the main causes of mortality and morbidity in older adults[3].

The finger-tapping task (FTT) has been widely implemented to evaluate motor ability and muscular control because the FTT is simple and easy to perform. The FTT has been extensively utilized for assessing the clinical course and prognosis in patients with ataxia, acute stroke, alcoholic Korsakoff's syndrome, and Alzheimer disease[4]. For example, one study among patients with stroke reported that speed of finger tapping correlates with scores of the Barthel Index and the Frenchay Activities Index[5], while another study demonstrated that healthy older adults show significantly slower tapping rates than young adults[6]. In addition, the variability of the intertap intervals and frequency of delayed taps increase with age, and these changes cannot be explained simply by grip strength and tactile sensitivity of the fingertips[7]. Various functions of the hand are essential for ADLs[8]. Previous studies revealed that grip strength is a prognostic indicator for mortality and physical function[9-11]. However, no information is available on prognostic implications of finger-tapping speed in healthy older adults.

Therefore, the aim of this study was to investigate the prognostic impact of finger tap reaction time on physical performance and to determine whether finger tap reaction time results can be used as independent prognostic markers for poor functional outcome in older adults.

MATERIALS AND METHODS

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1. Study Design and Participants

The study was a cohort-based study. All participants were treated according to a protocol approved by the Institutional Review Board of Seoul National University Bundang Hospital (approval number: B-0912-089-005) and informed consent was obtained. The study was a part of the Korean Longitudinal Study on Health and Aging (KLoSHA), which were investigated and evaluated issues of health, aging, and geriatric disease in Korean community-dwelling older adults. In total, 1,000 participants (439 men and 561 women) participated in the KLoSHA and baseline data were acquired between September 2005 and August 2006. A more detailed description of the cohort can be found in the previously published article[12].

At baseline, 633 participants performed the FTT. Among them, 178 were lost to follow-up, and 21 could not finish the test. We excluded one outlier considered to be an error from data input for further analysis. This left 433 participants who comprised the final study group (Fig. 1).

Demographic and functional data were collected at baseline. After 5 years, data on physical function, ADLs, and history of falling were collected, and the mortality data for 5 years were obtained from the National Statistical Office (Statistics Korea).

The primary endpoint was a composite of mortality and deterioration in physical performance. The "poor-outcome group" included participants who died within 5 years and who showed poor physical performance with SPPB scores of less than 10. Secondary endpoints were fall events, inability to perform a 400-m walking test, and decline in function of ADLs.

To assess motor performance, we applied the FTT. A personal computer running the SuperLab software (Cedrus Corp., San Pedro, CA, USA) was used to present stimuli and record responses. The method employed was modified from the protocol used in the previous study[13]. In brief, a signal stimulus followed a warning stimulus on the screen and participants were instructed to push the button with their index finger as fast as possible, immediately after watching the signal stimulus. A total of 20 blocks were tested for each participant. Each block consisted of 5 randomly arranged trials according to the 5 different intervals separating the warning and signal stimuli (500, 625, 750, 875, and 1,000 msec). The average latency (latency from the signal stimulus to the participant's reaction) from 100 trials was defined as the elapsed time. Based on the median value (5,403.75 msec) of the elapsed time for all participants, subjects were categorized into 2 groups: the fast-reaction group (reaction time <5,403.75 msec) versus the slow-reaction group (reaction time ≥5,403.75 msec).

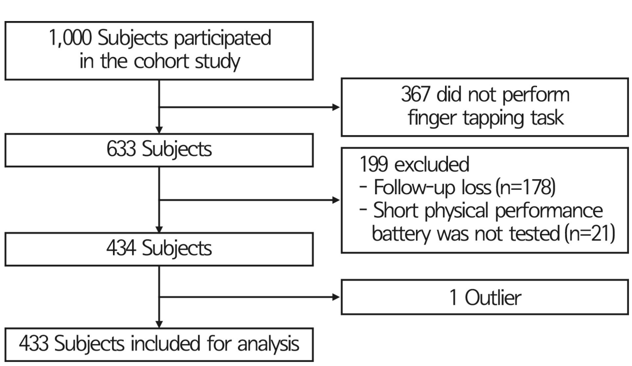

Fig. 1. Flow diagram illustrating the process of subject inclusion for final analysis.

Hand grip strength was measured following a standardized protocol[14] during 2 consecutive trials. It was measured in kilograms while the participant maintained a neutral position of the arm, forearm, and wrist. The Jamar 5030J1 hydraulic dynamometer (Sammons Preston, Bolingbrook, IL, USA) was used. Mean values for the dominant hand were used for statistical analysis.

The detailed methodology to measure knee extensor strength was described in a previous study[15]. In brief, we measured the isokinetic muscle strength of the right knee extensor using an isokinetic dynamometer (Biodex Isokinetic Tester, Biodex, Medical Systems, Shirley, NY, USA). Participants performed 2 sets of 5 repetitions of knee extensions and flexions. Average values of concentric peak torque from 2 sets were used for statistical analysis.

To assess physical performance, the SPPB was applied[16]. The SPPB is an objective assessment tool for evaluating lower extremity functioning in older adults and consists of three items: gait speed, chair stand, and balance test. For the gait speed, participants were instructed to walk at their usual speed and go all the way past the other end of the course. The distance of the walking course was 4 m. To test their ability to rise from a chair, participants were asked to rise up repeatedly (5 times) without using their upper extremities. Static balance was evaluated using three different stances (tandem stance, semi-tandem stance, and side-by-side stance). Each item was scored on a scale of 0 to 4 (4 for the best performance and 0 for the worst); thus, the total score ranged from 0 to 12. According to a previous study, the risk of disability in mobility rises sharply at scores below 10[17]. Participants also performed a 400-m walking test. The ability to complete 400-m walking and the time required to do so were measured[18].

ADLs were evaluated using Korean ADL (K-ADL) and Korean instrumental ADL (K-IADL) scores[19-21]. Seven domains such as dressing, washing face and hands, bathing, eating, transferring, toileting, and continence compose the K-ADL, and 10 domains such as decorating, housework, preparing meals, doing laundry, going to a nearby place, using transportation, shopping, handling money, using the telephone, and taking medicine compose the K-IADL. Each domain was scored on a 3-point scale ranging from 1 to 3, with a score of 1 given for independent ADL and a score of 3 for totally dependent ADL. In sum, a person with total independence will score 7 points for K-ADL, and 10 points for K-IADL. Poor prognosis was defined as the deterioration of scores over time.

The Mini-Mental Status Examination in the Korean version of the Consortium to Establish a Registry for Alzheimer's Disease Assessment Packet (MMSE-KC) was used to assess cognitive function[22]. The maximum score of the MMSE-KC is 30. In older adults, the association between depression and functional disability was identified in previous studies[23,24]. The Center for Epidemiological Studies-Depression Scale was used to evaluate depressive mood among participants in the present study[25]. We collected mortality data during the study period from the National Statistical Office (Statistics Korea). The duration of follow-up was 5 years, and the length of survival was calculated from the date of mortality. At the 5-year follow-up, we asked all participants if they had experienced a fall during the previous year. They were also asked about the frequency, time, and place of falls.

2. Statistical Analysis

We presented all statistics as the mean and standard deviation, and conducted the analyses with PASW Statistics 18 (SPSS Inc., Chicago, IL, USA).

An independent sample t-test was performed to compare the two groups (good- and poor-outcome groups) for continuous variables and chi-square analysis was done for nominal variables. Associations between the FTT and primary and secondary outcomes (i.e., deterioration in physical performance, fall events, ability to complete a 400-m walking test, and K-ADL score) were analyzed using multiple logistic regression analysis.

RESULTS

Demographic data and functional measures at baseline are presented in Table 1. A primary composite endpoint (mortality and deterioration in physical performance measured by the SPPB) occurred in 176 patients (poor-outcome group), and the other 257 participants were in the good-outcome group. For the poor-outcome group, 56 participants died and 120 showed poor physical performance (SPPB score <10) after 5 years. There were significant differences between the 2 groups in all variables. Participants in the good-outcome group showed a higher proportion of male sex, younger age, faster finger tap reaction time, better grip strength, higher cognitive function, greater independence in ADLs, and less depression. The median follow-up was 39.2 months (range, 2.1-41.8 months).

To determine the prognostic implications of the finger tap reaction time, multiple logistic regression analysis was used. Before analyzing, associations and collinearities between variables were assessed. We excluded knee extensor strength from this analysis, because it had a strong positive correlation and collinearity with grip strength. Factors affecting mortality or poor physical performance were old age, poor cognitive function, depressive mood, and lesser grip strength. Slow finger tap reaction time was a significant risk factor for poor functional outcome even after adjusting for other variables (Table 2). The odds ratio of poor functional outcome in the slow-reaction group was 2.22, with a 95% confidence interval of 1.37 to 3.58. Multiple regression analyses results for secondary outcomes are also shown in Table 2. None of the independent variables were significantly associated with a fall event. Age, grip strength, and cognitive function were significant prognostic factors for performance of the 400-m walking test. For K-ADL, almost all participants achieved a score of 7 at both the initial and follow-up evaluations; thus, statistical analysis could not be performed. There

Table 1. Demographic data and functional status at baseline

Characteristic	Good-outcome group (n=257)	Poor-outcome group (n=176)	p-value*
Age (yr)	70.6±5.1	77.2±8.8	<0.001
Male sex	154 (59.9)	73 (41.5)	<0.001
Finger tapping reaction time (msec)	5,461.1±255.4	5,607.3±403.9	<0.001
Grip strength (kg)	22.3±9.2	14.8±7.3	<0.001
MMSE-KC score	26.0±2.8	22.7±4.5	<0.001
K-ADL score	7.0±0.2	7.2±0.7	0.014
K-IADL score	11.6±3.0	12.9±4.3	<0.001
CES-D score	30.8±7.4	34.5±10.5	<0.001

Values are presented as mean±standard deviation or number (%).
MMSE-KC, Mini-Mental Status Examination in the Korean version of the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) Assessment Packet; K-ADL, Korean Activities of Daily Living; K-IADL, Korean Instrumental Activities of Daily Living; CES-D, Center for Epidemiological Studies-Depression Scale.
*p-values obtained by t-test or chi-square test.

Table 2. Multiple logistic regression models and odds ratios (95% confidence interval) for each functional outcome

Variable	Poor outcome (mortality or poor physical performance)	Fall (during the last 1 yr)	Failure of 400-m walking test	Deterioration of K-IADL
Finger tapping				
Fast reaction	Reference	Reference	Reference	Reference
Slow reaction	2.22 (1.37–3.58)*	0.86 (0.51–1.41)	1.52 (0.90–2.59)	1.31 (0.83–2.07)
Age (yr)	1.10 (1.06–1.15)*	1.02 (0.99–1.06)	1.06 (1.02–1.11)*	1.05 (1.01–1.09)*
Sex				
Female	Reference	Reference	Reference	Reference
Male	1.17 (0.61–2.25)	1.11 (0.54–2.26)	0.84 (0.40–1.78)	3.94 (2.06–7.51)*
Grip strength	0.97 (0.95–0.99)*	1.00 (0.98–1.01)	0.98 (0.96–1.00)*	1.00 (0.99–1.02)
K-ADL	1.77 (0.72–4.39)	0.89 (0.52–1.54)	2.24 (0.73–6.90)	0.52 (0.19–1.44)
MMSE-KC	0.88 (0.81–0.96)*	0.93 (0.86–1.00)	0.91 (0.83–0.99)*	0.97 (0.89–1.05)
CES-D	1.04 (1.01–1.06)*	1.01 (0.98–1.04)	1.03 (1.00–1.06)	1.01 (0.98–1.04)

K-ADL, Korean Activities of Daily Living; K-IADL, Korean Instrumental Activities of Daily Living; MMSE-KC, Mini-Mental Status Examination in the Korean version of the CERAD Assessment Packet; CES-D, Center for Epidemiological Studies-Depression Scale.
*$p<0.05$.

was a trend toward a deterioration of the K-IADL score in the slow-reaction group; however, it was not statistically significant.

DISCUSSION

The present study demonstrates that motor reaction time of the FTT is an independent prognostic factor for mortality or decline in physical performance, and has great value in predicting long-term prognosis of older adults. In our sample, the finger tap reaction time among participants showed small variability and the difference in finger tap reaction time between the good- and poor-outcome groups was small. However, there was a significant prognostic difference between the fast-reaction and slow-reaction groups.

Slowing of motor speed is related to long-term poor prognosis in older adults. One large pooled analysis of nine cohort studies, using individual data from 34,485 older adults, revealed that gait speed at baseline is associated with long-term survival[26]. Slow reaction time may be associated with impaired function of multiple organ systems including the musculoskeletal, cardiovascular, and central and peripheral nervous systems in various diseases[27-30]. Additionally, greater decline in physical function or mortality could be observed in patients with a slow reaction time.

Previous studies have demonstrated the correlation between lesser grip strength and risk of functional deterioration[12]. The present study reaffirms that grip strength is a significant prognostic factor for functional decline in older adults. We think that both measurement of finger tap reaction time and grip strength could be used extensively in the clinical setting due to their convenience and simplicity. However, compared to the measurement of grip strength, measurement of finger tap reaction time reflects multiple physical functions such as agility, visuomotor coordination, cognition, concentration, and endurance. In this study, only a weak negative correlation between grip strength and finger tap reaction time was observed (Pearson correlation coefficient, $r=-0.19$), suggesting that there is no trade-off between grip strength and finger tap reaction time. Neither was there collinearity between the 2 measurements. Our results suggest that each tool independently reflects different aspects of functional decline with age, without trade-off or collinearity. Moreover, this explanation was supported by the results of multiple logistic regression analysis, which revealed both grip strength and finger tap reaction time independently had prognostic implications for functional decline, even after adjusting for other factors.

However, our study has some limitations. First, our primary endpoint was a composite of mortality and deterioration in physical performance. Mortality as a single endpoint was not statistically relevant because relatively few mortalities occurred over 5 years. Likewise, deciding to only use another single endpoint of physical performance might have caused survival bias. Therefore, we used a composite endpoint that combined both mortality and deterioration in physical performance for better statistical analysis. Second, the study population was limited to participants who were able to perform the FTT and participate in a 5-year follow-up evaluation. Participants with severe physical disability might have been excluded from this study at baseline due to their inability to perform the FTT. Finally, fatigue encountered during the FTT may induce slowed finger tap reaction time. Arias et al.[31] reported that the fast mode of the FTT has the potential to affect the validity of the test. Therefore, further studies concerning variables other than finger tap reaction time such as intertapping variability would be helpful to minimize the effect of fatigue on the validity of FTT.

In the present study, a significant increase in the risk of mortality or deterioration in physical performance was observed in the slow-reaction group performing the FTT compared with in the fast-reaction group. We conclude that delayed finger tap reaction time is an independent prognostic factor for poor functional outcome in 5 years in older adults.

Conflicts of Interest Disclosures: The researchers claim no conflicts of interest.

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