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A Lower Prevalence of Self-Reported Fear of Falling Is Associated with Memory Decline among Older Adults

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Key Words
Elderly · Fear of falling · Memory · Falls · Cognitive decline

Abstract
Background: In spite of a number of reports about various factors associated with the fear of falling (FoF) among older adults (such as age and physical function), the relationship between FoF and cognitive decline remains unclear. ***Objective:*** To determine which cognitive function is related with the prevalence of FoF in older adults. ***Methods:*** Participants were 101 older adults (mean age 75.1 years; 48.5% males). Of these, 54 older adults (53.4%) were classified as the fear group on the basis of the presence of FoF. Age, gender, the Timed Up and Go test (TUG), fall history, the Alzheimer's Disease Assessment Scale, the Wechsler Memory Scale-Revised-Logical Memory I (WMS-LM I), the delayed memory test, digit symbol coding, digit span and verbal fluency were measured as potential relevant factors. ***Results:*** Logistic regression analysis revealed that TUG [odds ratio (OR) 1.43, 95% confidence interval (CI) 1.12–1.83; p = 0.004], WMS-LM I (OR 1.20, 95% CI 1.07–1.35; p = 0.002) and fall history (OR 4.38, 95% CI 1.53–12.51; p = 0.006) were independently associated with FoF. ***Conclusions:*** The results suggest that a lower prevalence of self-reported FoF is associated with memory decline among older adults. Insensitivity to FoF may be one of the characteristics of psychological change with memory decline.

Introduction

Fear of falling (FoF) refers to a lack of self-confidence that normal activities can be performed without falling [1]. Other authors define FoF as a general concept that describes low fall-related efficacy (low confidence in avoiding falls) and being afraid of falling [2]. The prevalence of FoF ranges from 33 to 40%, is higher in women and increases with age [3, 4]. FoF is associated with poor health status [2, 5], functional decline [6, 7], psychological problems [8, 9] and restriction of activities [4, 10]. It is considered important to reduce FoF by targeting down-

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stream factors, such as increasing physical functioning [11]. In spite of a number of reports about various factors associated with FoF, there is no literature examining the relationship between FoF and cognitive functions that inevitably decline with age.

Several aspects of age-related decline of cognitive function are well documented and contribute to the deterioration of the ability to carry out tasks in activities of daily living. For example, memory difficulty is related to slower performance of timed instrumental activities of daily living tasks [12]. Additionally, cognitive impairment is one of the key factors contributing to accidental falls [13]. Recent evidence indicates that even mild cognitive decline is a risk factor for falls [14]. In seniors with Mini-Mental State Examination (MMSE) scores greater than 24 out of 30, baseline cognitive performance was found to be linearly and inversely associated with the rate of falling over 8 years [14]. Within the multiple domains of cognitive function, impaired executive function and memory decline are predictive of accidental falls in older adults [14–16] and are prevalent even in healthy, community-dwelling seniors without dementia (MMSE score >24) [17, 18]. FoF has been recognized as an important psychological factor associated with accidental falls and restricting everyday functioning [19–21]. In addition to studying the risk of falling, investigation of FoF may also be key to the medical management of older adults with mild cognitive decline. Cognitive function includes several domains, such as general, memory, processing speed, language and executive function. However, no previous studies have reported which cognitive declines contribute to the experience of FoF in older adults.

The purpose of this study is to determine the relationship between FoF and potential correlates in older adults with cognitive decline and to identify which cognitive declines are associated with FoF. This investigation is critical to the exploration of psychological factors associated with accidental falls and restricting everyday functioning, enabling the planning of future rehabilitation programs that prevent falls and maintain activities in older adults with cognitive decline.

Methods

Participants

The participants were recruited from two volunteer databases (n = 1,543), which included elderly participants aged 65 years and over who were selected by random sampling or attended a health check in Obu. In the first eligibility assessment for this study, 528 potential participants were enrolled. One hundred and sixty-five participants responded to the second eligibility assessment, and 108 participants completed the assessment and met the inclusion criteria. The inclusion criteria were that they had to be living independently in the community, Japanese-speaking and able to participate in the examinations, and they had to have adequate hearing and visual acuity. In addition, general cognitive function was found to be intact in all 108 participants, whose MMSE scores were in the range of 24–30 [22]. Seven participants were excluded based on the following exclusion criteria: a history of major psychiatric illness, other serious neurological or musculoskeletal diagnoses or depression (Geriatric Depression Scale score $\geq$10 [23]). The final sample used for analysis consisted of 101 older adults (mean age 75.1 years; 48.5% males; mean educational history 10.7 years). This study was approved by the ethics committee of the National Center for Geriatrics and Gerontology. All participants provided written informed consent.

Measurements

Demographic data were recorded, including age, gender, educational history and number of medications. FoF was assessed by a fourth-ordered choice, closed-ended question about participants' general FoF. The question was phrased as follows: 'Are you afraid of falling?' Participants who responded 'very much' or 'somewhat' were assigned to the fear group; participants who responded 'a little' or 'not at all' were assigned to the no-fear group [24] , which had a high test-retest reliability of up to 0.9 in a sample of 44 randomly selected individuals [25].

The participants also completed a standardized questionnaire that recorded the number of times they had fallen in the past year. A fall was defined as an event where a person unintentionally comes to rest on the ground, floor or another lower level [26]. Falls resulting from extraordinary environmental factors (e.g. traffic accidents or falls while riding a bicycle) were excluded from the count. On the basis of their fall history, participants were divided into two groups, namely fallers (1 or more falls) and nonfallers (0 falls).

The participants underwent 3 clinical measurements to assess physical performance, namely the Timed Up and Go Test (TUG), the one-leg standing test and the 5-meter walking test, in the presence of an experienced physiotherapist. The TUG [27] involves rising from a chair, walking 3 m, turning around, walking back to the chair and sitting down. Participants were instructed to complete the task at their usual pace. The score represented the time in seconds that the participant needed to complete the assessment. Less time taken to accomplish this task indicated better balancing and gait ability. The shorter time measured in the two trials was recorded as the TUG score. In the one-leg standing test, the participants were asked to stand on their preferred leg as long as possible with their arms hanging down and with eyes open. One-leg standing balance was measured as the time (0–120 s) participants could stand on one leg. The longer time measured in the two trials was recorded as the one-leg standing test score. In the 5-meter walking test, participants were asked to walk along a straight, level path at their 'normal walking speed'. Walking time was calculated using a stopwatch to measure the time taken to cover the central 5 m of the walkway (2 m at the start and finish were used for acceleration and deceleration). The walking time score was calculated as the shorter time in seconds for completion of two trials.

All neuropsychological tests were conducted by well-trained speech therapists, and each score was rechecked by a single speech

Table 1. Demographic and clinical characteristics of study participants

	Fear group (n = 54)	No-fear group (n = 47)	p value	Effect size
Age, years	76.2 ± 6.8 (65–93)	73.7 ± 6.7 (69–94)	0.071	0.37
Education, years	10.5 ± 2.2	11.0 ± 2.8	0.251	0.20
Males	20 (37.0)	29 (61.7)	0.013	0.25
Number of medications	2.8 ± 2.2	2.0 ± 2.3	0.087	0.36
GDS score	3.3 ± 2.4	2.7 ± 2.2	0.232	0.26
Fall history	21 (38.9)	9 (19.1)	0.030	0.22
TUG, s	9.7 ± 2.6	8.5 ± 2.1	0.013	0.51
One-leg standing test, s	31.3 ± 23.7	41.1 ± 23.2	0.041	0.42
5-Meter walking time, s	5.0 ± 1.8	4.6 ± 1.1	0.12	0.27

Values are means ± SD (range) or numbers of participants (%). GDS = Geriatric Depression Scale. Effect sizes are based on Cohen's d (t test) or ϕ (χ^2).

therapist who was blinded to the other data of the participants in this study. General cognitive function was evaluated using the Alzheimer's Disease Assessment Scale (ADAS) [28]. The ADAS was designed specifically to evaluate cognitive and behavioral dysfunctions characteristic of Alzheimer's disease. On this test, the scores range from 0 to 70 points, with fewer points indicating a better score.

Memory function was evaluated by the Logical Memory I (story A only) from the Japanese version of the Wechsler Memory Scale-Revised (WMS-LM I) [29]. On this task, a short story that consisted of 25 segments was read aloud to the participant, who was instructed to recall details of the story immediately. On this test, the scores ranged from 0 to 25 points, with more points indicating a better score. The delayed memory test was also conducted, which is a three-word recall test in the MMSE [22]. In this study, delayed memory was converted to categorical variables, i.e. 0 (1 or more mistakes with the three words) or 1 point (all three words correct).

Processing speed was assessed by using a version of the digit symbol coding subtest of the Wechsler Adult Intelligence Scale III [30]. In the test, participants copied symbols that are paired with numbers. Using the key provided at the top of the exercise form, the participant drew the symbol under the corresponding number. The score for digit symbol coding was the number of correct symbols drawn within 120 s. One point is given for each correctly drawn symbol completed within the time limit, for a maximum score of 133.

Executive function was assessed using the Trail Making Test, part B [31]. Participants were required to navigate a series of alternating numbers and letters and connect them in alternating sequential order. The time required to complete each task was recorded, with more time indicating worse performance.

We also conducted a digit span forward test and a digit span backward test. Both tests are a subset of the Wechsler Adult Intelligence Scale III [30] and require participants to repeat a series of verbally presented digits of increasing length in forward and backward order. Performance on the digit span task strongly depended upon working memory, cognitive regulation and manipulation, all of which are components of executive function. The score recorded, ranging from 0 to 14, was the number of successful sequences.

Verbal fluency is composed of letter fluency and category fluency [32]. The participants were asked to generate as many words as possible within 1 min, consisting of an initial letter (letter fluency) and an animal name (category fluency) [33]. Verbal fluency is an evaluation of expressive language ability and executive function [32–34]. The score was the number of successful words (except for some proper nouns).

Statistical Analysis

Unpaired t tests or χ^2 tests (for gender, fall history and delayed memory) were used to evaluate the differences in measurements between the fear and no-fear groups. Cohen's d (t test) or ϕ (χ^2) values were calculated as measures of effect size.

Logistic regression analysis, performed as a stepwise analysis, was carried out to examine whether the potential determinants were independently associated with FoF. In this analysis, the presence or absence of FoF was used as the dependent variable (no-fear = 0, fear = 1), and age and variables that showed a significant difference between the fear and no-fear groups were employed as independent variables. Gender and fall history were created as categorical variables (male = 0, female = 1; nonfaller = 0, faller = 1). Statistical analyses were conducted using software package SPSS version 11.0 (SPSS Inc., Chicago, Ill., USA), and $p < 0.05$ was accepted as significant.

Results

Fifty-four older adults out of 101 participants (53.4%) were classified into the fear group, and 47 older adults (46.6%) were classified into the no-fear group. Table 1 shows the differences in demographic variables and physical performance test scores between the fear and no-fear groups. There were no significant differences in age, educational history or number of medications. The fear group had a lower number of males than the no-fear group (fear group 37.0%, no-fear group 61.7%; p = 0.013),

Table 2. Cognitive characteristics of study participants

	Fear group (n = 54)	No-fear group (n = 47)	p value	Effect size
MMSE score	26.9 ± 2.2	27.2 ± 1.6	0.565	0.16
ADAS score	6.0 ± 3.5	6.2 ± 2.5	0.853	0.07
WMS-LM I score	8.5 ± 4.3	6.6 ± 4.6	0.033	0.43
Score of 1 on the delayed memory test	35 (64.8)	20 (42.6)	0.029	0.22
TMT-B, s	192.6 ± 82.9	180.6 ± 118	0.573	0.12
Digit symbol coding score	46.1 ± 15.2	48.1 ± 16.2	0.526	0.13
Digit span forward score	4.9 ± 0.1	4.9 ± 0.3	0.063	0
Digit span backward score	4.5 ± 0.8	4.5 ± 0.7	0.851	0
Letter fluency score	5.3 ± 3.1	6.1 ± 3.7	0.270	0.24
Category fluency score	15.1 ± 4.9	14.7 ± 4.4	0.691	0.09

Values are means ± SD or numbers of participants (%). TMT-B = Trail Making Test, part B. Effect sizes are based on Cohen's d (t test) or ϕ (χ^2).

while the number of fallers among the fear group was significantly higher than among the no-fear group (fear group 38.9%, no-fear group 19.1%; p = 0.03). With regard to physical performance tests, the fear group exhibited better scores on the TUG (p = 0.013) and one-leg standing test (p = 0.041) than the no-fear group. There were no significant differences in 5-meter walking time (p = 0.12).

Among several domains of cognitive function, only memory function showed significant differences between the groups. The fear group had significantly more points on the WMS-LM I (p = 0.033) than the no-fear group. More participants in the fear group than in the no-fear group scored 1 point on the delayed memory test (p = 0.029). There were no statistically significant differences in the MMSE, ADAS, digit symbol coding subtest, Trail Making Test, part B, digit span forward test, digit span backward test, letter fluency and category fluency between the groups (table 2).

Age, gender, fall history, TUG, WMS-LM I and delayed memory were entered into a stepwise logistic regression model. Logistic regression analysis revealed that TUG [odds ratio (OR) 1.43, 95% confidence interval (CI) 1.12–1.83; p = 0.004], WMS-LM I (OR 1.20, 95% CI 1.07–1.35; p = 0.002) and fall history (OR 4.38, 95% CI 1.53–12.51; p = 0.006) were independently associated with FoF, accounting for age and gender. Age, gender and delayed memory did not show a statistically significant relationship (table 3). The model was well calibrated between declines of observed and expected risk (Hosmer-Lemeshow χ^2 = 5.4, p = 0.72).

Table 3. Factors associated with FoF in stepwise logistic regression

Factor	OR	95% CI	p value
TUG	1.43	1.12–1.83	0.004
WMS-LM I	1.20	1.07–1.35	0.002
Fall history	4.38	1.53–12.51	0.006
Age	–	–	0.32
Gender	–	–	0.13
Delayed memory test	–	–	0.16
One-leg standing test	–	–	0.27

Discussion

This is the first study to clarify the relationship between cognitive decline and experience of FoF. It is in line with studies that show the prevalence of FoF is higher in females and in individuals with worse physical function (i.e. worse scores on the TUG and one-leg standing tests) and a history of falls [25, 35]. The results of the present study revealed that memory function was also significantly associated with FoF, which indicates that a lower prevalence of FoF is associated with memory decline among older adults, although there were no significant associations between FoF and other cognitive functions (i.e. general, processing speed, language and executive function). Interestingly, it can be suggested that worse physical function is likely to cause FoF, while worse memory function is likely to inhibit FoF in older adults.

Among the various cognitive functions, memory decline may influence FoF specifically. It might be difficult for nondemented participants with memory decline to recall detailed images of accidental falls. Memory decline is the initial symptom of dementia. Older adults with even very mild dementia are inclined to underestimate their functional deficits and have poor insight into depressive symptoms and behavioral changes, which is regarded as 'anosognosia' [36]. In the present study, it is possible that participants with memory decline may also have underestimated functional deficits, the risk of accidental falls and 'post-fall syndrome', which may lead to insensitivity to FoF. We considered that insensitivity to FoF may be one of the characteristics of psychological changes in older adults with memory decline.

Low prevalence of FoF might reduce the effect of rehabilitation programs on fall prevention and the maintenance of activities in older adults with memory decline. It was reported that multimedia patient education to prevent falls was not effective for patients with impaired cognitive function, although the same education reduced falls among patients with intact cognitive function [37]. These authors suggested that cognitive impairment can limit the ability of patients to adhere to planned safety-promoting behaviors. Arai et al. [38] reported that exercise intervention for physical function outcome might be beneficial to older adults with lower confidence for performing various activities without falling compared with those with higher confidence. It is possible that FoF in a way contributes to safety-promoting behaviors and adherence to exercise intervention. Therefore, insensitivity to FoF may be one of the factors reducing the effect of education and exercise intervention to prevent falls. It is possible that education and an exercise program specifically designed to address their cognitive needs and insensitivity to FoF is more beneficial for preventing falls among participants with memory decline.

This study has several limitations. Firstly, the sample size was relatively small. Secondly, as with other cross-sectional studies, the design of the current study limits the interpretation of the results with regard to causality between memory decline and FoF. A longitudinal study will be necessary to examine the causal relationship between memory decline, future fall incidence and expression of FoF. Thirdly, we did not collect data on certain factors that may influence FoF, such as perception of health [4] and emotional support [39]. These and other factors should be examined in future FoF studies.

In conclusion, memory decline is a specific aspect of cognition influencing experience of FoF in addition to physical function and fall history. The major implication of this study is that FoF was not only associated with worse physical performance but also memory function, which indicates that a lower prevalence of FoF is associated with memory decline among older adults. Insensitivity to FoF may be one of the characteristics of psychological change in older adults with memory decline. Future research is needed to clarify the causal relationship between memory decline, future fall incidence and expression of FoF.

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Brain Atrophy and Trunk Stability During Dual-Task Walking Among Older Adults

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Background. Dual-task walking is believed to be more cognitively demanding than normal walking and alters trunk movement among older adults. However, the possible association between brain atrophy and spatiotemporal gait parameters, particularly during dual-task walking, is poorly understood. In this study, we examined the relationship between dual-task walking and brain atrophy.

Methods. One hundred ten elderly adults (aged 65–94 years, women $n = 55$) underwent magnetic resonance imaging scanning and gait experiments under normal and dual-task walking conditions. Linear accelerations of the trunk were measured in vertical, anteroposterior, and mediolateral directions using a triaxial accelerometer attached to the lower trunk. Gait speed, stride length, and cadence were recorded. The harmonic ratio, a measure of trunk stability, was computed separately in each direction to evaluate the smoothness of trunk movement during walking. Brain atrophy was quantitatively assessed using magnetic resonance image data.

Results. Gait speed, stride length, cadence, and harmonic ratio in all directions were lower in dual-task walking than in normal walking ($p < .05$). The dual-task–related changes in harmonic ratio were independently correlated with brain atrophy adjusted for subject characteristics only in the vertical direction ($p < .05$).

Conclusions. Our findings support the hypothesis that dual-task walking is more cognitively demanding than normal walking. Decreased trunk stability during dual-task walking is associated with brain atrophy. Additional studies are necessary to elucidate the effects of regional brain atrophy on the control of walking.

Key Words: Brain atrophy—Gait analysis—Dual-task walking—Acceleration.

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SUCCESSFUL locomotion is thought to require stability during gait. During normal walking, control of trunk movement is prioritized and contributes to head stability to maintain gait stability (1). Age-related gait changes among older adults induce trunk instability, which is reflected in reduced smoothness of trunk motion (2,3), and is more pronounced during more challenging walking tasks than during normal walking (4). Walking is a motor task that requires consecutive movement and adaptability to a changing environment. Successful locomotion not only requires input from the neuromuscular system but also from high-order cognitive systems such as executive function.

The performance of executive function has been associated with gait performance, and this relationship is stronger during more challenging walking tasks such as dual-task walking (5,6,7). To investigate the cognitive demands of walking, dual-task walking has been researched, for example, walking while performing a cognitive task or walking while talking. Dual-task walking markedly increased the variability of lower limb gait variables in older adults with cognitive impairment (8,9) and even in healthy older adults (10,11,12). Additionally, dual-task walking affected trunk movement in healthy older adults (7,13,14,15). Cognitive demands during dual-task walking affect spatiotemporal gait parameters. Dual-task–related changes (DTC) in gait variables correlate with both mobility and cognitive function in healthy older adults with normal gait performance (5). Moreover, dual-task training involving mobility tasks improved not only mobility function but also cognitive function (16, 17). Thus, dual-task walking may require and activate more multidomain neural resources in the brain than normal walking.

Emerging evidence suggests that age-related changes in the brain are linked to mobility deficits. Examples of these age-related changes include structural changes and changes to the biochemistry in the brain (18). Changes in the white matter (19,20,21) or the volume of gray matter (21,22,23), that is, macrostructural changes seen on magnetic resonance images (MRI), are also associated with changes in gait parameters. MRI-based measures of atrophy are a neurodegeneration marker, and they correlate with cognitive deficits and disease progress (24). However, a consensus has not been reached on which specific gait parameters are related to brain atrophy. Furthermore, it is still unclear if DTC in gait variables, including trunk movement, are related to MRI-based markers.

The purpose of this study was to investigate the relationships between brain atrophy and spatiotemporal gait parameters during normal and dual-task walking in older adults. We hypothesized that DTC in spatiotemporal gait parameters in older adults are related to brain atrophy described by MRI-based markers. To acquire quantitative gait variables including variables describing trunk movement and for a variety of conditions, we used a triaxial accelerometer that minimizes restrictions of walking movements (25). Brain atrophy was quantitatively and automatically calculated using a voxel-based analysis system from MRI (26,27).

Methods

Participants

One hundred thirty-five people were recruited from our volunteer database, which included older adults aged 65 and older. The inclusion criteria required that participants were living independently in the community and had adequate speech, hearing, and visual acuity to participate in the examinations. Exclusion criteria included having a history of major psychiatric illness, serious neurological or musculoskeletal diagnoses, or depression [Geriatric Depression Scale score $\geq$ 10 (28)]. Each participant underwent gait experiments and assessments including a face-to-face interview with a clinical nurse, a cognitive assessment by a speech therapist, physical performance tests, and MRI scanning. One hundred ten people met the criteria and participated in this study. The following data were recorded: age, sex, body mass index, and educational history. To assess functional capacity, we used the Tokyo Metropolitan Institute of Gerontology Index of Competence (29) questionnaire (0–13 points). This questionnaire consists of three subscales and each item has 1 point: instrumental self-maintenance (five items), intellectual activity (four items), and social role (four items). General physical function was examined using grip strength and the timed up and go test (30). Grip strength was measured twice while standing, and the higher value was used. The timed up and go test is a mobility test, and participants were asked to walk 3 m, then turn around and walk 3 m, all at their self-selected normal speed in a well-lit environment. Neuropsychological function was evaluated using the Mini-Mental State Examination (31). The ethics committee of the National Center for Geriatrics and Gerontology approved this study. All participants provided written, informed consent.

Gait Analysis

Participants were checked to make sure they were wearing shoes of an appropriate size before each experiment. Then, subjects were instructed to walk on an 11-m smooth, horizontal walkway, with a 2-m space at both ends of the walkway for acceleration and deceleration. Two gait experiments were performed in order: (a) normal walking at the participant's preferred speed and (b) dual-task walking: walking while counting backward in double digits with a randomly chosen starting number between 50 and 99. The mid 5-m walking time was measured, and gait speed was expressed in meters per second. A triaxial accelerometer (MVP-RF8, acceleration range: $\pm$60 m/sec^2, size: 45 mm width, 45 mm depth, 18.5 mm height, weight: 60 g, sampling rate: 200 Hz; MicroStone, Nagano, Japan) was attached to the L3 spinous process using a Velcro™ belt. The accuracy of data acquisition had been confirmed in a previous study using the same type of sensor (32). Before measurements, the accelerometer was calibrated statically against gravity. After analogue to digital transformation (10-bit resolution), signals were immediately transferred to a laptop PC (Let's Note CF-W5, Panasonic, Osaka, Japan) via a Bluetooth Personal Area Network. The working range of the accelerometer to the PC was approximately 50 m. Signal processing was performed using commercially available software (MATLAB, Release 2008b, The MathWorks Japan, Tokyo, Japan). The person who processed the acceleration data was blinded to any other results. Before analysis, all acceleration data were low-pass filtered (dual pass zero lag Butterworth filtered) with a cutoff frequency of 20 Hz. Stride time was determined by a validated method reported as the interval from an initial contact event to the next ipsilateral event (33). The mean stride time was calculated from five consecutive stride times. The average stride length was determined by multiplying gait speed by mean stride duration. The harmonic ratio (HR) was used to evaluate the smoothness and stability of trunk movement during gait (3,4,34). Higher HR values indicate greater stability during walking. HR was computed using a digital Fourier transform separately in each direction (vertical: VT direction, mediolateral direction, and anteroposterior direction). The procedure for calculating HR has been reported elsewhere (3,4,34).

Brain MRI

MRI was performed on a 1.5-T system (Magnetom Vision, Siemens, Germany). Three-dimensional volumetric acquisition of a T1-weighted gradient echo sequence was used to produce a gapless series of thin sagittal sections using a magnetization preparation rapid-acquisition gradient echo

sequence (repetition time, 1700 ms; echo time, 4.0 ms; flip angle 15°, acquisition matrix 256 × 256, 1.3 mm slice thickness). The voxel-based specific regional analysis system in this study has been validated (26,27). This system was reformatted to produce gapless 2-mm thin-slice transaxial images, and the first anatomical standardization used affine transformation. The normalized MRI images were then segmented into gray matter, white matter, cerebrospinal fluid, and other components using a modified version of the clustering algorithm, the maximum likelihood "mixture model" algorithm. The segmentation procedure involved a calculation for each voxel using a Bayesian probability of belonging to each tissue class based on a priori MRI information with a nonuniformity correction. The segmented gray matter images were then subjected to an affine and nonlinear anatomical standardization using an a priori gray matter template. The anatomically standardized gray matter images were smoothed with an isotropic Gaussian kernel 12-mm full-width at half-maximum to exploit the partial volume effects, and a spectrum of gray matter intensities was created. We compared the gray matter image of each patient with the mean and standard deviation of gray matter images of healthy volunteers using voxel-by-voxel *Z* score analysis. In the final step, the *Z* score was calculated according to the following equation:

$$Z \text{ score} = ([\text{control mean}] - [\text{individual value}]) / \text{control } SD$$

The region of brain atrophy was defined as voxels with a *Z* score greater than 2. The brain atrophy index was defined as the proportion of the number of voxels defined atrophic relative to the total number of voxels of the entire brain.

Statistical Analysis

All analyses were performed using commercially available software (JMP8.0J for Windows, SAS Institute Japan, Tokyo, Japan). The data were normally distributed for all spatiotemporal gait parameters under both normal walking and dual-task walking conditions. Gait parameters were compared between normal walking and dual-task walking using a repeated measures analysis of variance. To assess the association between DTC in gait parameters and brain atrophy, we first confirmed the interaction of the factors brain atrophy (continuous measure) and walking condition (normal walking vs dual-task walking) for each gait parameters using a repeated multivariate analysis of covariance adjusted for covariates (covariates: age, sex, and Mini-Mental State Examination score). Covariates for the interaction were then confirmed using an analysis of variance comparing tertiles of brain atrophy. A linear regression model adjusted for gait speed was used to detect a significant association between brain atrophy and DTC in those gait parameters with a significant interaction between brain atrophy and walking condition. Independent variables included subject characteristics and DTC in gait parameters between walking conditions and were presented as percentage of changes (|dual-task walking − normal walking|/normal walking × 100). Statistical significance was set a priori at $p < .05$.

Results

The 110 subjects (50% women) were aged between 65 and 94 years with a mean body mass index of 23.1 kg/m^2. The demographic data, general physical performance, functional capacity, and brain atrophy for all subjects are summarized in Table 1. The spatiotemporal gait parameters under normal walking and dual-task walking conditions and a comparison between conditions are presented in Table 2. Gait speed was significantly lower for the dual-task walking compared with the normal walking condition even when adjusted for sex ($p = .029$). Stride length and cadence were lower for dual-task walking condition compared with the normal walking condition even when adjusted for sex and gait speed (stride length: $p < .001$, cadence: $p < .001$). The HR of trunk movement in all directions was significantly lower for the dual-task walking condition compared with the normal walking condition even when adjusted for sex and gait speed (VT direction: $p < .001$, mediolateral direction: $p = .002$, anteroposterior direction: $p < .001$). The repeated multivariate analysis of covariance revealed a significant interaction between walking condition (normal walking vs dual-task walking) and brain atrophy only for HR in VT direction (walking condition × brain atrophy: $F = 4.334$, $p = .040$). Linear regression analysis revealed that brain atrophy is independently related to DTC in HR in VT direction ($\beta = .231$, $p = .024$; Table 3).

Discussion

This study revealed that decreased trunk stability during dual-task walking is significantly associated with brain atrophy in older adults. This association was independent of other variables in a regression model. In addition, dual-task walking resulted in a change of spatiotemporal gait parameters compared with normal walking, even when adjusted for sex and gait speed. The deterioration in HR during dual-task walking

Table 1. Subject Characteristics and Percentage of Brain Atrophy

Characteristics	*M* ± *SD*
Age (y)	75.4 ± 7.1
Sex, women subjects (%)	55 (50)
Body mass index (kg/m^2)	23.1 ± 3.3
Educational history (y)	10.7 ± 2.6
Mini-Mental State Examination (total score)	26.4 ± 2.5
Grip strength (kg)	23.5 ± 7.5
Timed up and go test (seconds)	9.2 ± 2.3
Geriatric Depression Scale (total score)	3.7 ± 3.0
Tokyo Metropolitan Institute of Gerontology Index of Competence (total score)	12.2 ± 1.1
Brain atrophy (%)	7.6 ± 4.2

Notes: Values are mean ± *SD* and numbers (proportion) for sex. Brain atrophy was calculated using a specific voxel-based regional analysis system for MRI data.

Table 2. Paired Comparison of Spatiotemporal Gait Parameters for Normal Walking and Dual-Task Walking

Variables	Normal Walking ($M \pm SD$)	Dual-Task Walking ($M \pm SD$)	Mean Difference (95% CI)	p Value	Adjusted p Value*
Gait speed (m/s)	1.10 ± 0.26	1.04 ± 0.31	−0.05 (−0.10, −0.01)	.022	.029†
Stride length (m)	1.13 ± 0.21	1.19 ± 0.41	0.06 (−0.01, 0.13)	.103	<.001
Cadence (steps/min)	115.8 ± 12.3	107.6 ± 17.8	−8.0 (−12.21, −3.80)	<.001	< .001
Harmonic ratio					
Vertical	2.84 ± 0.86	2.44 ± 0.81	−0.38 (−0.64, −0.12)	.005	<.001
Mediolateral	2.12 ± 0.65	1.95 ± 0.53	−0.19 (−0.36, −0.01)	.036	.002
Anteroposterior	3.13 ± 1.04	2.61 ± 0.83	−0.53 (−0.79, −0.25)	<.001	<.001

Notes: CI = confidence interval.
*Adjusted for sex and gait speed.
†Adjusted only for sex.

was observed in all three directions. However, the association between brain atrophy and DTC in HR was only present in VT direction.

Both the motor system and the cognitive system act reciprocally to ensure successful locomotion. To investigate this interaction, many experiments have been conducted using the dual-task method (10,11,12). DTC in gait parameters among older adults as a result of cognitive motor interference reflect an adaptation to a more challenging conditions and the fact that locomotion requires high-order cognitive processing such as executive function (5,6,7). Dual tasking generally affects spatiotemporal gait parameters including lower extremity (10,12) and trunk movement (7,13,14,15). Our results were consistent with reported dual-task changes for spatiotemporal gait measures, although the magnitude of changes varied among gait variables, type of tasks, or task difficulty (10,12). Dual tasking decreases HR as indicated by decreased smoothness of trunk movement and increased trunk instability in all directions. Furthermore, decreased HR may be caused by an adaptation because similar changes in HR have been reported for walking with additional challenges (eg, walking on an irregular surface) (4). The DTC in spatiotemporal gait parameters observed in our study suggest that dual tasking influences the control of both lower extremity and trunk movement.

Table 3. A Linear Regression Model for Brain Atrophy

	Brain Atrophy	
Variables	β (SE)	p Value
Age	.352 (.004)	<.001
Gender	.462 (.034)	<.001
Body mass index	.240 (.007)	.010
Educational history	−.028 (.010)	.779
Mini-Mental State Examination score	−.143 (.011)	.164
Grip strength	−.082 (.005)	.540
Tokyo Metropolitan Institute of Gerontology Index of Competence	.072 (.023)	.469
Geriatric Depression Scale	.249 (.008)	.016
Dual-task–related changes of HR in VT direction	.231 (.062)	.024
R^2		.362

Notes: HR = harmonic ratio; VT = vertical. A linear regression model was used to examine the association between dual-task–related changes of the gait parameter and brain atrophy, adjusted for gait speed.

MRI-based measures of brain atrophy are valid parameters because macrostructural brain abnormalities inevitably lead to neurodegeneration, neuropsychological deficits, tangle deposition, and microstructural loss (24). The macrostructural brain abnormalities associated with gait are hyperintensities of the white matter (19,20,21) and atrophy of the gray matter (21,22,23). The brain volume in the sensorimotor and frontoparietal regions including the prefrontal lobes is associated with step time and double support time during normal gait (22), and the differences between intracranial and brain volume were independently related to slower gait speed in women after adjusting for covariates (21). While one study reported that hippocampal volume is related to gait speed (23), results of another study suggest that gait performance among older adults is not necessarily related to atrophy in the memory domain including the hippocampus (22). The latter study also reported a weak association between gait measures and brain volume in the cerebellum or basal ganglia structures—regions that play key roles in the control of balance. A consensus has not been reached on the relationship between quantitative MRI-based measures of brain atrophy and gait variables. The results of our study indicate that DTC in trunk movement is significantly related to brain atrophy measured using the voxel-by-voxel method, which has been validated in other studies (26,27). Rosano and colleagues (22) suggested that gait variables under several conditions, including difficult conditions, should be investigated to clarify the task-specific network in the brain. Our initial results indicate that DTC in trunk movement might be associated with brain atrophy.

The control of trunk movement contributes to successful locomotion and is under continuous active neural control (1). The neural network may prioritize trunk stability to increase head stability during walking (35). Additionally, dual-task walking requires successful allocation of attention to both walking and the other task, which relies on executive function. In fact, dual-task decrements of gait measures are related to cognitive performance such as executive function (5,6,7), and both mobility and cognitive function are enhanced by dual-task intervention training as shown by results of randomized clinical trials (16,17). Because dual-task walking requires the

simultaneous control of walking and an additional task, the demand on neural resources for postural adjustments during walking may be greater for dual-task walking compared with normal walking. The analysis of HR during dual-task walking revealed an association between DTC in HR and brain atrophy; however, there was no relationship between DTC in other gait variables and brain atrophy. These results suggest that HR during dual-task walking may be a biomechanical marker for identifying a decline in brain volume.

Although dual-task walking decreased HR for trunk movement in all directions, an association between brain atrophy and DTC in HR was only observed in VT direction. These observations agree with results of other studies that HR data for lower trunk acceleration may represent different phenomena depended on the direction (2,36). Menz and colleagues (2) reported that directional specificity in HR in older adults was greater while walking under more challenging conditions. Results of their study suggested that the HR value of the lower trunk in VT direction had the ability to detect instability under challenging conditions. In another study, Brach and colleagues (3) suggested that HR in anteroposterior direction represents age-related changes that are not even affected by gait speed. The directional specificity of HR was not fully clarified, and further evidence for this specificity is required. Nevertheless, the results of our study indicate that brain atrophy is more likely to be related to trunk instability in the VT direction than in the anteroposterior and mediolateral directions induced by dual-task walking.

One limitation of this study is the relatively small sample size. Additionally, some physical dimensions, such as fitness level (37) and static postural instability (38), may have acted as confounding factors but were not included in this study. Furthermore, the effects of executive function and attention as confounding factors could influence dual-task gait performance (6,12) and should be considered to generalize these results. Moreover, the type and/or difficulty of dual-task walking in this study could have affected the results. Hence, dual-task walking using other types of cognitive tasks (eg, verbal fluency) should further be investigated. Finally, in this study, we measured atrophy of the entire brain. It is likely that regional atrophy assessed by MRI and other macrostructural measures (eg, white matter lesions) will provide a better insight into the mechanistic relationship between brain atrophy and gait function.

Conclusion

Brain atrophy correlated with a decline in the control of trunk movement during dual-task walking. This result indicates that dual-task walking induces trunk instability because additional cognitive resources are required compared with that during normal walking. Further studies are needed to clarify the effects of regional structural brain loss on the control of trunk movement and limb control during walking.

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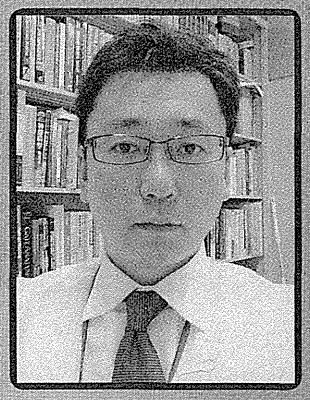
運動による現場での効果：とくに認知症予防の視点から



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はじめに

認知症は加齢とともに増加し、高齢者数の増大とともに有症者数が急激に増え、社会保障費を圧迫する原因となっている。実際に、わが国における認知症関連費用は約3兆5,000億円に達し、全世界においては米国に次ぐ世界第2位の費用となっている[1]。また、国民生活基礎調査による介護が必要となった主な原因を見ると、平成13年には認知症が原因で要介護となった者は10.7%（第4位）であったのが、平成22年には15.3%（第2位）となり、団塊世代が今後10～20年の間に認知症の好発年齢を迎える2025年頃には認知症高齢者の急増が見込まれ、その予防が急務の課題となっている。認知症の主な原因疾患であるアルツハイマー病および脳血管疾患に対する根治療法や予防薬の開発が確立されていない現在において、認知症の予防もしくは発症遅延のための非薬物療法の可能性を検討することも重要である。

本稿では、介護予防の新たな方向性として、認知症予防を目的とした認知機能の低下予防に有効な非薬物による介入の効果について概説する。

認知症予防の焦点

わが国における65歳以上の認知症有病率は約10%程度と推察されており、その有病者数は今後さらに増大することが懸念されている。中でも、認知症ではないが正常とも言い難い軽度の認知機能低下を有する状態は、軽度認知障害（mild cognitive impairment: MCI）と呼ばれ、認知症を発症する危険が高い[2]。地域に在住する高齢者を対象とした大規模疫学研究では、MCI有症率は概ね11～23%であり、このMCIは認知症に移行する危険性が高い反面、正常の認知機能に回復する場合もあり[3][4]、認知症予防を積極的に推進すべき状態と考えられる。

たとえば、健忘型MCI高齢者の半数、および非健忘型MCI高齢者の3分の2が、3年間の追跡期間中にアルツハイマー病へ移行することが示されている[5]。また、Petersenらの報告によると、正常な認知機能を有する高齢者におけるアルツハイマー病の発症率は年間1～2%であったのに対して、MCI高齢者におけるアルツハイマー病の発症率は年間10～15%であり、MCIはアルツハイマー病の前駆状態として考えられている。

一方、38.5%のMCI高齢者は5年後に正常な認知機能へと回復するとした報告もあり[7]、MCIの状態から可逆的変化を促すことが認知症を予防もしくは発症を遅延させることにつながるものと考えられる。そのため、認知症予防を目的とした介護予防においては、とくにMCI高齢者に焦点

を当てた取り組みが重要であり[6),8)]、その効果が期待される。

運動による認知症予防とそのメカニズム

薬物を使用しない療法による認知症予防としては、習慣的な運動の促進[9)]、抗酸化物質や抗炎症成分を多く含む食物の摂取[10)]、社会参加、知的活動、生産活動への参加[11)]、社会的ネットワーク[12)]が、認知症発症に対して保護的に働く因子として認められている。

中でも、有酸素運動の実施とアルツハイマー病発症予防との関連は多くの知見が得られており、MCI高齢者に対しても運動の効果を検証したランダム化比較試験の結果が報告され、限定的ではあるが認知機能に対する効果を認めている[13),14)]。運動介入プログラムはコストの面や実施しやすい点から、介護予防事業の中核を果たしている。

しかし、わが国において、運動が認知機能保持や認知症予防にどのような効果を持つかを検証した臨床試験は、未だほとんど実施されておらず、今後さらなる科学的根拠の構築が求められているところである。

運動が認知機能に対して良好な影響を及ぼすメカニズムとして、動物実験からの知見を中心に、神経炎症の減少、血管の新生、神経内分泌反応などが示唆されている。また、アルツハイマー病予防の観点からは、発症の原因と考えられているアミロイドβの蓄積を抑制する効果があるとされているネプリライシン[15)]の脳内活性が、身体活動と密接な関係を有しており、アルツハイマー病の予防に身体活動の向上が寄与する可能性が示唆されている[16)]。

近年では、運動を行うことにより活性化される脳由来神経栄養因子（brain derived neurotrophic factor: BDNF）が着目されており、認知機能の向上に寄与するとされている。とくにBDNFの効果は、記憶に重要な脳の海馬領域において観察され、可塑的変化をもたらすことが報告されている[17),18)]。また、運動の実施と脳容量増加、およびBDNFとの関係や、1年間の有酸素運動の実施による海馬容量の増加が報告されている[19)]。

BDNF以外にも運動による血管新生や、運動に伴うコリン作動性活性化による海馬の神経幹細胞活性などが明らかにされており、運動による認知機能向上のメカニズムが明白になりつつある。医療、保健、福祉の実践においても、運動によって対象者の認知的反応の向上を経験する機会があるが、それはこのような生理学的変化に基づいた帰結であると考えられる。

大府MCI介入研究

われわれはMCI高齢者を対象として認知症予防に対する運動の効果を検証するための研究事業を実施しており（主任研究者：鈴木隆雄国立長寿医療研究センター研究所長）、その研究結果の一部をここで紹介する。

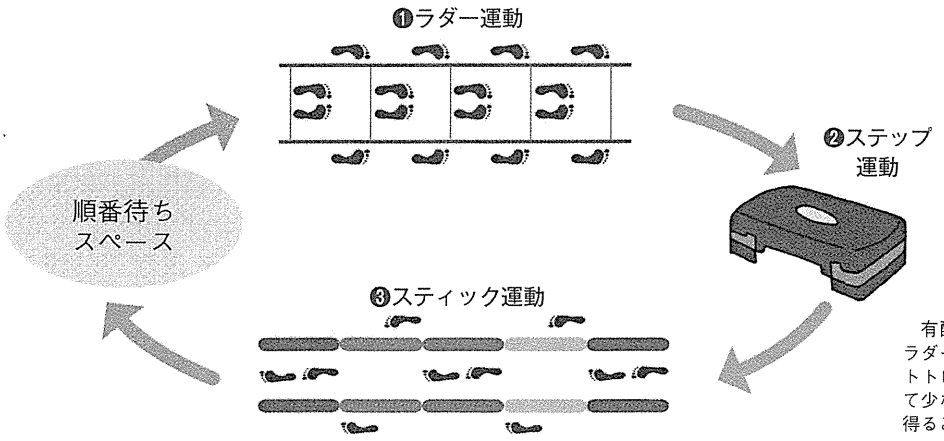
【対象者】

本研究の対象者は、愛知県大府市在住の65歳以上の高齢者。対象者の選定は、1次調査（質問紙調査n＝1,543）、2次調査（認知機能検査n＝135）、3次調査（MRI撮影n＝126）により実施した。基準に該当し研究への参加に同意した135名に対して認知機能検査を実施し、125名がMRI

図1　運動介入の方法

運動指導は理学療法士が担当し、補助員4名の体制で介入を実施した。プログラムの内容は、1）基礎体力作り（ホームプログラムとしても実施）、2）有酸素運動（ステップトレーニング、屋外歩行）、3）記憶力を必要とする運動（多重課題への適応、創造的思考などを伴う運動）、4）行動変容を促すプログラム（グループディスカッション、セルフモニタリング）により構成された。

図2　サーキットトレーニングの一例



有酸素運動であるステップ運動、脳賦活課題であるラダー運動・スティック運動を次々に行う「サーキットトレーニング」を介入後期に実施した。これによって少ない時間でさまざまな運動を実施でき高い効果を得ることが期待できる。

撮影を受けた。2次および3次調査で35名が除外基準あるいは参加を拒否し、100名のMCI高齢者が介入対象者として選択された。これらの対象者を健忘型MCIで層化して無作為に健康講座群（対照群）と運動教室群（介入群）とに割り付けた。

【介入プログラム】

運動教室群の介入は、6か月間、週2回、1回につき90分間、計40回実施した。教室は1日に3クラス設定し、1クラスの対象者を約17名として、理学療法士1～2名、運動補助員4名で介入を実施した。介入の内容は、ストレッチ、筋力トレーニング、有酸素運動、認知課題を含めた脳活性化運動（記憶や二重課題など）、行動変容技法による運動を習慣化とした（図1）。介入が後半に差しかかったあたりで、「サーキットトレーニング」を取り入れて、有酸素運動と脳賦活運動を組み合わせて、少ない時間でより効率的な介入になるよう工夫した（図2）。また、運動教室群の対象者には、歩数計の装着を促し、目標歩数への到達とストレッチ、筋力トレーニングの実施を毎日行うよう推奨した。

健康講座群には、介護や疾病予防に関する健康講座（60～90分間）を6か月間に2回実施した。

【結　果】

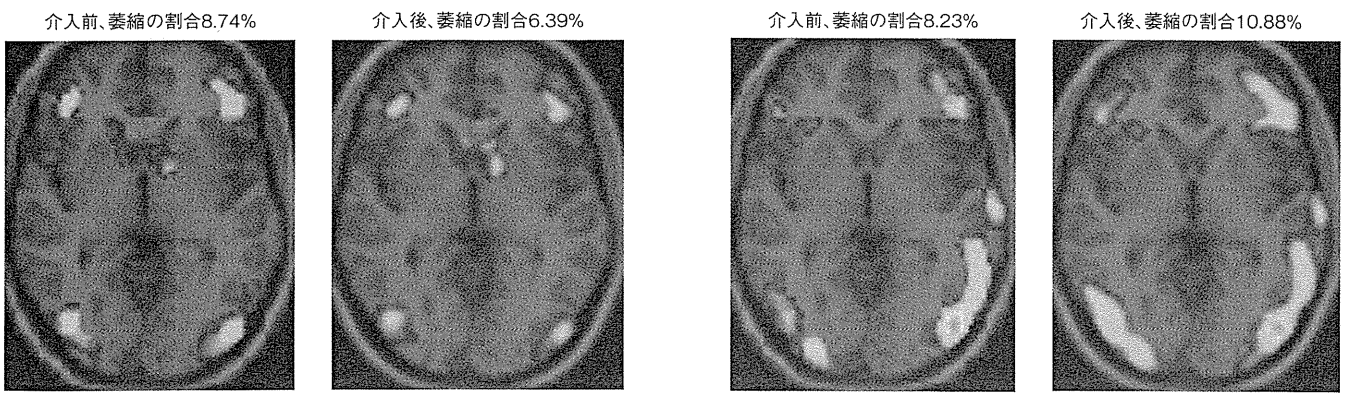
a. 運動教室の実施状況

運動教室群のうち38名（78%）が、40回の介入で80%以上出席した。また5名（10%）の対象者が30%以下の出席であった。運動教室実施中の有害事象はなかった。

b. 介入前の健康講座群と介入群の認知機能

ベースライン時における健康講座群と運動教室群間での比較において、年齢、運動機能、活動状態、教育歴、認知機能、脳容量のすべての項目で、全例および健忘型MCI

図3　MRI指標による脳萎縮の変化



典型的な変化を示した両群の対象者の例を図示した。運動教室に参加した高齢者（81歳、男性）は、介入期間中に脳萎縮の大きな変化は認められなかったが（左図）、健康講座に参加した高齢者（78歳、男性）では脳萎縮の割合が上昇した（右図）。

群ともに有意差は認められなかった。

c. 介入前後の認知機能の変化 ー全対象者ー

言語機能であるWord Fluency Test（カテゴリー課題）および遂行機能（digit symbol coding）において、運動介入群と健康講座群間に有意な交互作用が認められた。

d. 介入前後の認知機能の変化 ー健忘型MCI高齢者ー

健忘型MCI高齢者における群間差を比較した結果、Mini-Mental State Examination（全般的な認知機能）、ウェクスラー記憶検査、Word Fluency Test（言語機能）において、有意な交互作用が認められた。

e. 脳容量測定

介入前後の比較において、全対象者および健忘型MCI高齢者の両方の分析にて、健康講座群の脳萎縮領域の割合が有意に上昇した。群間比較では健忘型MCI高齢者の分析において、運動教室群と健康講座群間に交互作用が認められ、運動による脳萎縮の抑制効果が観察された（図3）。

まとめ

多面的な運動の実施は、MCI高齢者の認知機能の向上に有効であった。とくに、アルツハイマー病へ移行する危険性が高い健忘型MCI高齢者[20) 21)]の全般的な認知機能の保持や記憶機能の向上が運動によって認められたことは、認知症予防の可能性を示唆するものと考えられた。

おわりに

自ら実践可能な運動によって認知症予防の可能性が見えてきたことは、高齢者本人や社会にとって大きな希望となるだろう。ただし、運動の効果は一朝一夕になし得るものではなく、継続した取り組みが重要である。活動的に老いることが健康を保持するための鍵となり、これを支援するためのシステムの構築が急がれる。

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〈原　著〉

手段的日常生活活動の自立した地域在住高齢者における転倒恐怖感に関連する要因の検討

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要　約　**目的**：手段的日常生活活動（IADL）の自立した地域在住高齢者における転倒恐怖感の存在率及びその特徴を検討することを本研究の目的とした．**方法**：対象は，IADLの自立した地域在住高齢者119名（平均年齢75.7±7.2歳，女性60名）であった．問診により聴取した転倒恐怖感の有無により，転倒恐怖感を有している者をあり群，有していない者をなし群とした．過去1年間の転倒経験，過去1カ月における疼痛の有無，3種類以上の服薬の有無，そして慢性疾患の有無もあわせて聴取した．そして，身体活動量としてInternational Physical Activity Questionnaire；IPAQ，生活空間としてLife-Space Assessment；LSA，心理状態としてGeriatric Depression Scale；GDSを日本語版の質問紙を用いて調査した．さらに，身体機能としてTimed Up and Go test；TUG，開眼片足立ち保持時間を測定した．各指標に対する群間比較を連続変数には対応のないt検定，カテゴリー変数にはχ^2検定を用いて検討した．さらに転倒恐怖感の有無を従属変数とし，単変量解析で有意な差が認められた指標を独立変数とした多重ロジスティック回帰分析の強制投入法を用いて，転倒恐怖感に関連する要因を検討した．**結果**：転倒恐怖感を有する者は対象者全体の51.3%で，その全員が日常生活に支障はないと回答した．転倒恐怖感が，あり群ではなし群に比べ有意に女性，痛み，慢性疾患，転倒経験を有する者の割合が各々高かった．また，あり群の方が，LSAの得点が低く，TUGの所要時間が長く，開眼片足立ち保持時間が短く，各項目において有意な群間差がみられた（$p<0.05$）．多重ロジスティック回帰分析においてLSA（総得点120点）のみが転倒恐怖感の有無と有意に関連した（OR：0.96，95%信頼区間＝0.93～0.99）．**結論**：IADLが自立した地域在住高齢者の51.3%に転倒恐怖感が存在し，高い値を示した．転倒恐怖感は，多変量解析では，LSAとのみ関連があった．今後，縦断的な調査によりこの因果関係を明らかにし，効果的な介入方法を確立することが重要である．

Key words：地域在住高齢者，転倒恐怖感，生活空間

（日老医誌　2012；49：457-462）

緒　言

転倒恐怖感は，1980年代に，転倒後の心理的トラウマの結果起こるPost-fall syndromeの要素として定義された．高齢者は転倒を経験すると，再度転倒することに恐怖感をもち，移動の際，過度に注意を払い歩くようになる[1)]．一方で，転倒経験のない高齢者にも転倒恐怖感が存在することが明らかとなり新たな定義が1990年にTinettiらによって提唱された[2)]．それは「ある活動を行う機能は保たれているにもかかわらず，それを避けるように働く転倒に対する不安」というものであり，日常生活活動に支障を来たす恐怖感として定義された．その後転倒恐怖感の存在率やその発生に関係する因子を同定する研究が多くなされてきた．

2008年に報告されたSystematic reviewによると，転倒恐怖感は地域在住高齢者の21～85%に存在すると報告されている[3)]．転倒恐怖感の発生に関係する因子は，最も多く報告されているものが過去の転倒経験[1)5)]であった．また，加齢や女性であることなどの基本属性[6)7)]，慢性疾患の既往歴，服薬，疼痛などの健康状態[6)7)]，歩行，バランス機能低下[8)]，抑うつや不安などの心理状態[9)10)]が

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転倒恐怖感と関連する因子として明らかとなっている．さらに，縦断的な研究では，転倒恐怖感を有する地域在住高齢者は，将来，日常生活活動（Activity of daily living，以下ADLと略す）障害を引き起こしやすい[11]という報告もされておりその重要性は明確である．

これまでの研究では，転倒恐怖感によりADLに影響のある高齢者についての報告が多くなされているが，一方で，転倒恐怖感はあるが日常生活に支障はないと回答する対象者も多く存在すると報告されている[12]．しかし，ADLの保たれた高齢者にどの程度，転倒恐怖感が存在し，それが，どのような因子と関連しているかは明らかではない．

本研究では，手段的日常生活活動（Instrumental activity of daily living，以下IADLと略す）が自立した地域在住高齢者の転倒恐怖感の存在率，及びその関連要因を検討することを目的とした．

方　法

対象者は，国立長寿医療研究センターが保有する65歳以上の地域在住高齢者を対象としたデータベース（n＝1,543）から，重度の脳卒中，心疾患の既往のある者と明らかに調査が遂行できないと判断された者を除外した．さらに，調査協力が得られ全ての検査が実施できた者から，IADLが自立していない高齢者を除外し，119名（平均年齢75.7±7.2歳，男性59名，女性60名）を本研究の対象とした．なおIADLの評価は老研式活動能力指標を用い，手段的自立の項目である「バスや電車を使って1人で外出できますか」「日用品の買い物ができますか」「自分で食事の用意ができますか」「請求書の支払いができますか」「銀行貯金・郵便貯金の出し入れが自分でできますか」に全て「はい」と回答した者をIADL自立とした．対象者には本研究の主旨および目的を口頭と書面にて説明し，書面にて同意を得た．なお，本研究は国立長寿医療研究センター倫理・利益相反審査委員会の承認を受けて実施した．

転倒恐怖感の聴取は，「現在，転ぶことに対してどのような怖さを持っていますか」と質問し，「全く怖くない」「怖くない」「やや怖い」「大変怖い」の4つの選択肢から回答を求め，「全く怖くない」「怖くない」と回答した者を転倒恐怖感なし群とし，「やや怖い」「大変怖い」と回答した者を転倒恐怖感あり群とした．さらに，転倒恐怖感が日常生活に影響を及ぼすかどうかを聴取した．

調査項目は，これまで転倒恐怖感に関連すると報告されている基本属性，健康状態，転倒歴，運動機能，心理状態に加えより高次の能力を評価するため身体活動量と生活空間の指標も含めた．基本属性として年齢，性別を聴取し，身長と体重を測定しBody Mass Index（以下BMIと略す）を算出した．健康状態については，慢性疾患の既往歴，服薬，痛みを聴取した．慢性疾患の既往歴において，高血圧，糖尿病，心疾患，脳血管疾患のいずれかの既往がある場合を「慢性疾患の既往歴あり」とした．先行研究で転倒の予測因子として報告されている服薬数に着目し[13]，現在飲んでいる薬を種類ごとに尋ね，合計3種類以上の服薬がある場合を「3種類以上の服用あり」とした．痛みは，健康関連QOLの一側面として捉えている先行研究に着目し[14]，SF-8の痛みに関する下位項目を用い，「過去1カ月間に身体の痛みはどのくらいありましたか」という質問に対し，「ぜんぜんなかった」「かすかな痛み」「軽い痛み」「中くらいの痛み」「強い痛み」「非常に強い痛み」の中から回答を求めた．「ぜんぜんなかった」を選択した者を「痛みなし」とし，その他5項目を選択した者を「痛みあり」とした．転倒歴は過去1年間の転倒回数を尋ね，1回以上転倒している者を「転倒経験あり」とした．転倒はGibson MJの定義[15]に基づき，「滑ったり，転んだり，つまずいたりなどしてバランスを崩し，足以外の体の一部が地面に触れたこと」とし，あらかじめ対象者に説明した．

身体機能検査としてTimed Up and Go test（以下TUGと略す），開眼片足立ち保持時間を測定した．TUGは椅座位から起立し3mを往復歩行した後に椅子へ着座するまでの所要時間をストップウォッチにて計測した．「普段歩いている速度」で2回計測を行い，所要時間の短い結果を採用した[16]．開眼片足立ち保持時間は，視線の高さに設定された視標点を注視しながら任意の脚を挙上し，片脚立位姿勢を保持するようにした．挙上脚が床面に接した時，あるいは立脚側が移動した時を終了とした．最大60秒までの時間を，ストップウォッチを用い2回測定し，保持時間の長い結果を採用した．心理状態はGeriatric Depression Scale（以下GDSと略す）を用いて調査した．GDSは15項目の質問に，「はい」か「いいえ」で答えるもので，得点は0～15点で得点が大きいほどうつ傾向が強いことを示す[17]．

身体活動量は，International Physical Activity Questionnaire（以下IPAQと略す）を用いた．IPAQは，1週間における高強度および中等度の身体活動を行う日数および時間を質問するものである．全9問から構成され，活動強度別に活動量を質問するshort versionを使用した[18]．生活空間の評価はLife-Space Assessment（以下LSAと略す）を用いた[19][20]．LSAは，各生活空間レベルに移動した頻度，移動における補助具（杖や車椅子）の

表1　各変数の全例及び転倒恐怖感の有無による比較

変数	全例（n＝119）	転倒恐怖感	
		あり（n＝61）	なし（n＝58）
年齢（歳）	75.7±7.2	76.6±6.8	74.8±7.0
性別（女性，%）	60（50.4）	40（65.6）	20（34.5）*
BMI（kg/m²）	23.1±3.3	22.9±3.6	23.2±3.0
慢性疾患の既往歴有り（人数，%）	54（45.4）	31（50.8）	23（39.7）*
3種類以上の服用有り（人数，%）	49（41.2）	29（47.5）	20（34.5）
痛み有り（人数，%）	76（63.9）	46（75.4）	30（51.7）*
転倒経験有り（人数，%）	40（33.6）	29（47.5）	11（19.0）*
TUG（秒）	9.1±2.3	9.6±2.4	8.5±2.0*
開眼片足立ち保持時間（秒）	33.3±23.8	28.8±22.8	40.0±23.5*
GDS（点）	3.6±3.2	4.0±3.4	3.4±2.9
IPAQ推定カロリー（kcal/日）	411.9±479.4	317.8±357.3	475.9±544.3
LSA（点）	95.5±17.6	88.2±18.6	101.1±15.2*

数値は平均値±標準偏差または人数（%）
対応のないt検定及びχ^2検定　*$p<0.05$
BMI＝Body Mass Index
TUG＝Timed Up and Go test
GDS＝Geriatric Depression Scale
IPAQ＝International Physical Activity Questionnaire
LSA＝Life-Space Assessment

必要性・介助者の必要性を調査する評価指標である．生活空間は，1）自宅内，2）自宅敷地内，3）自宅近隣，4）町内（概ね16 km以内），5）町外（概ね16 km以上）の5段階における移動の有無を聴取した．頻度は，週1回未満，週1～3回，週4～6回，毎日の4段階評価を各生活空間で聴取した．各生活空間得点（1～5点）に頻度（毎日：4点，4～6日：3点，1～3日：2点，1日未満：1点）と自立度の得点（自立：2点，物的介助あり：1.5点，人的介助あり：1点）を乗じて各生活空間の得点を算出した後，それら得点の和を算出してLSA得点とした．得点は0～120点となり，得点が大きいほどより生活空間が広く自立して活動できていることを意味している．以上の質問紙票はすべて日本語版を用いた．なお，調査項目はすべて事前にトレーニングを受けたスタッフが行った．

統計解析は，転倒恐怖感の有無によりわけられた2群間の比較を，連続変数に対しては対応のないt検定，カテゴリー変数にはχ^2検定を用いて検討した．これらの分析で有意な群間差を示した指標と転倒恐怖感の関連性を検討するために，多重ロジスティック回帰分析を行った．目的変数に転倒恐怖感の有無を，説明変数に有意な群間差を認めた項目に共変量として年齢，性別を加え，検討を行った．性別と「はい」と「いいえ」で表す名義尺度には女性と「はい」を1，男性と「いいえ」を0のダミー変数で表した．また，転倒恐怖感の有無でのLSAの下位項目を細かく検討するために，各生活空間レベルへの移動頻度，補助具の有無，介助者の有無と転倒恐怖感の有無にχ^2検定を行った．統計解析はSPSS for Windows 17.0を用い，有意水準は5%とした．

結　果

全対象者の特性及び転倒恐怖感の有無で分けた群ごとの特性を表1に示した．対象者のうち61名（51.3%）が転倒恐怖感を有していた．なお，転倒恐怖感を有する対象者は，全員，日常生活に影響はないと回答した．

基本属性では，年齢とBMIは群間において有意な差はなかったが，性別では，なし群（34.5%）に比べ，あり群（65.6%）に有意に女性が多かった（$p<0.05$）．健康状態では，「3種類以上の服用あり」では，有意な差はなかったが「過去1カ月に痛みあり」と「慢性疾患の既往歴あり」が転倒恐怖感あり群に有意に多く存在した（$p<0.05$）．

TUGでは，あり群（9.6±2.4秒）の方が，なし群（8.5±2.0秒）に比べ有意に遅く（$p<0.05$），開眼片足立ち保持時間では，あり群（28.8±22.8秒）が，なし群（40.0±23.5秒）に比べ有意に短かった（$p<0.05$）．LSAでは，あり群（88.2±18.6点）がなし群（101.1±15.2点）に比べ有意に低値を示した（$p<0.05$）．

単変量解析で有意な差を示した性別，「過去1年間の転倒経験」，「過去1カ月の痛み」，「慢性疾患の既往歴」，

表2　転倒恐怖感を従属変数とした多重ロジスティック回帰分析

独立変数	オッズ比	オッズ比の95%信頼区間	
		下限	上限
年齢（歳）	0.99	0.91	1.07
性別（女/男）	2.01	0.80	5.06
慢性疾患の既往歴（有/無）	0.69	0.26	1.83
痛み（有/無）	2.58	0.99	6.68
転倒経験（有/無）	0.60	0.22	1.66
TUG（秒）	1.06	0.79	1.40
開眼片足立ち保持時間（秒）	0.98	0.96	1.01
LSA（点）	0.96*	0.93	0.99

*p＜0.05
TUG＝Timed Up and Go test
LSA＝Life-Space Assessment

表3　転倒恐怖感の有無におけるLSAの下位項目の分布

LSA下位項目		転倒恐怖感	
		あり（n＝61）	なし（n＝58）
自宅近隣	頻度		
	毎日	57	58
	週4～6回	5	0
	補助具（あり）	1	0
	他者の助け（あり）	0	0
町内	頻度*		
	毎日	29	48
	週4～6回	12	7
	週1～3回	17	3
	週1回未満	3	0
	補助具（あり）*	6	0
	他者の助け（あり）	1	0
町外	頻度		
	毎日	8	14
	週4～6回	3	9
	週1～3回	25	23
	週1回未満	22	11
	なし	4	1
	補助具（あり）*	5	0
	介助者（あり）*	9	2

数値は人数
すべての対象者が補助具，介助者を必要とせず「自宅内」「自宅敷地内」に毎日移動しているため2項目を割愛
χ^2検定　*p＜0.05

TUG，開眼片足立ち保持時間，LSAと年齢を独立変数として多重ロジスティック回帰分析の強制投入法を用いた結果を表2に示す．LSA（オッズ比：0.96，95%信頼区間；0.93～0.99　p＝0.004）が転倒恐怖感の有無と独立して関連性を示し，他の変数では有意な関連は示されなかった．

表3にLSAの下位項目の分布を転倒恐怖感の有無で，群ごとに示した．LSAの町内の項目では，転倒恐怖感あり群で，なし群に比べ，有意に移動頻度が少なく，補助具を必要とする者が多かった．町外の項目では，あり群で，なし群に比べ，有意に補助具，介助者を必要とする者が多かった．

考　察

本研究では，IADLが自立した65歳以上の地域在住高齢者119名を対象とし転倒恐怖感の存在率及びその関連する要因を検討した．その結果，転倒恐怖感は対象者の51.3%に存在し，その全員が転倒恐怖感は日常生活に支障はないと回答した．転倒恐怖感の有無による群間比較では性別，慢性疾患の既往歴の有無，痛みの有無，過去1年間の転倒経験の有無，TUG，開眼片足立ち保持時間，LSAが有意な差および関連を示し，それらと年齢を独立変数とした多重ロジスティック回帰分析では，LSAのみが転倒恐怖感の有無と有意な関連性を示した．

転倒恐怖感に関する先行研究では，転倒恐怖感の存在率は21%～85%と報告されているが，存在率が85%を示す研究[3]では，対象者の取り込みがプライマリーケアを受診した者であり，他の報告よりもより虚弱な高齢者が対象となったものと考えられる．その研究を除くと21%～60%である．一方，本研究では，IADLが自立している者に対象を絞ったにもかかわらず51.3%と地域在住高齢者全体を対象としたこれまでの報告と比べても同等の値であった．

これまでの報告では，日常生活に影響のある転倒恐怖感は，年齢や性別などの基本属性に加え過去の転倒経験[4)5)]，健康状態[6)7)]歩行，バランス[8)]などの身体機能，さらに抑うつや不安[9)10)]などの心理的状態と関連があり，また，転倒恐怖感を有する高齢者は，有さない者に比べ，将来の日常生活活動障害を引き起こしやすい[11)]と報告されている．本研究の結果も過去の研究と一部合致し，さらに生活空間については新たな関連が示された．IADLが自立している高齢者の転倒恐怖感は，これまでの報告とは性質が異なるものと考えられる．さらにLSAの下位項目の分布から，自宅の近所よりも広い範囲，つまり町内や町外に移動する頻度や，その際に補助具，介助者が必要かどうかと転倒恐怖感が関連するということが示唆される．

生活空間の狭小化は，高齢者の生理的予備能の低下を