Introduction

According to an estimate by the Ministry of Health, Welfare and Labor, there are approximately 1.7 million-bedridden older adults in Japan in 2010 and it will increase to 2.3 million in 2025.[1] Also, the survey showed that 12% of older adults in a bedridden state occurred as a consequence of falls and related injuries, which are the second greatest cause after stroke. While the incidence of stroke almost remained unchanged for the last 10 years, fractures are reported to have increased by 1.5 times during this decade.[2] In Japan, bedridden older persons remain a major medical and social problem. Greater attention should be directed to falling, because it is one of the direct causes of older persons becoming bedridden.

Falls are frequent and recurrent problems among older people and one of the major incidences that affect the activities of daily living (ADL) and quality of life (QOL). One in three persons over 65 years of age and almost half of those who were over 80 years of age reportedly fell at least once a year.[3] The chance of recurrent falls increases with advancing age and it was reported that 8–17% of those who were 75 years or older[3] sustained multiple falls.[3–6] The consequences of falls include hip fractures, soft tissue injuries,[7–10] fear of falling,[10] hospitalization, increased immobility and greater disability.[9] Furthermore, falls can lead to loss of self-confidence in one's ability to perform routine daily tasks, eventually relating to the occurrence of social withdrawal (sometimes termed "post-fall syndrome").[11]

Various risk factors of falls have been raised based on the results of both retrospective and prospective studies. These factors include age, number of chronic diseases, body composition, muscle strength, functional mobility and performance measures related to balance function.[12–14] Previous studies have shown that decreased muscle strength of lower extremities and the balance instability lead to the fall.[15] Most previous findings related to falls risk have been based on both clinical evaluation methods[16] and self-reported confidence to accomplish ADL, but not many of which were gained from the results of actual physical performance tests.[17]

Activities of daily living is a term commonly used in a wide spectrum of disciplines, and there are many factors that may contribute to ADL such as age, functional ability and balance in old age, but its definitions and conceptualization vary from health status to life satisfaction. Conventionally, various instruments such as the Barthel Index (BI)[18] and Functional Independence Measure (FIM)[19] had been used for the assessment of ADL.

Because falls and their consequences have a major impact on functional prognosis in the older population, rehabilitation programs, which aim to reduce the risk of falling by augmenting all contributing factors such as muscle strength, flexibility and balance, have the potential to both decrease the risk of falling and improve ADL of older adults.

It was confirmed that women had a higher risk of falling than men.[20] It has been speculated that there are various intrinsic factors that make women more prone to falls than men, such as history of osteoporotic fracture after menopause, self-confidence on falling, lower muscle strength and worse physical performances. Differences in muscle strength and body composition are known to exist between men and women, and from early adulthood on, women have, on average, 30–40% less muscle strength than men.[21]

In order to propose rehabilitation strategies for the reduction of falls risk, thereby preventing falls in older women, the present study was designed to explore physical and functional factors related to actual incidence of falls during a 6-month follow-up period.

Methods

Subjects

Female patients aged 65 years and older, who were attending the Geriatric Outpatient Clinic of Nagoya University Hospital, participated in this study. The study was performed according to the principles of the Declaration of Helsinki and approved by the Ethics Committee of Nagoya University School of Medicine, Japan, in December 2007.

Exclusion criteria were: (i) hospital admission within 6 months; (ii) uncontrolled hypertension; (iii) dementia (Mini-Mental State Examination [MMSE][22] ≤15); (iv) ischemic heart disease or heart failure; (v) chronic obstructive pulmonary disease; and (vi) acute orthopedic pain and presence of neurological impairments.

Prior to the data collection, a written informed consent was obtained from each patient participating. After having obtained informed consent, all subjects were instructed to complete a questionnaire. It was designed to assess the risk of falls by scoring, and had 22 questions[23] including one asking about history of falls in the previous year (full score, 22). Those who scored 6 and above were regarded as subjects at risk of falls,[24] and were included in the present study. Eventually, 58 female patients (mean age ± standard deviation, 80.5 ± 5.7 years) were subjected to analyses. (Fig. 1)

All the participants had their medical background obtained by asking existing or previous history of illness, type of drugs used, existing physical complaints and geriatric syndromes. All the participants were then subjected to assessments of ADL, gait and balance, and muscle strength. Detailed descriptions of the assessments are provided below.

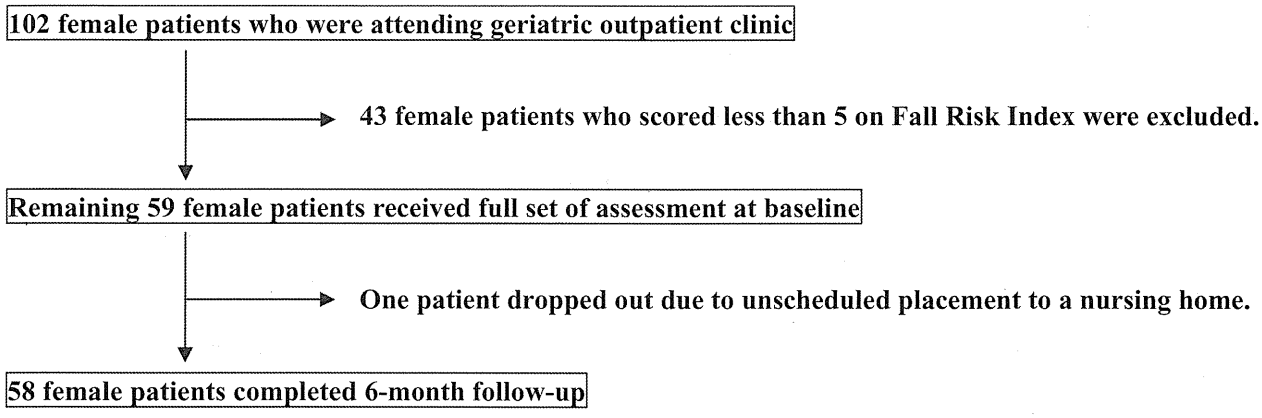

Figure 1 Flowchart showing the selection procedure of participants.

Assessment of ADL

The BI and FIM were used to assess ADL. Specific items in both scales are described elsewhere. In brief, BI is the most commonly used scale to assess one's basic ADL, and it consists of 10 items and scores range 0–100 points, with a higher score indicating greater ability. FIM is an 18-item, seven-level scale of independent performance in self-care, sphincter control, transfers, locomotion, communication and social cognition. The possible total score range from 18 (lowest) to 126 (highest level of independence).

Assessment of gait and balance

The Timed Up and Go test (TUG),[25] Functional Reach test (FR),[26] Berg Balance Scale (BBS)[27] and the Motor Fitness Scale (MFS)[28] were used to evaluate stability, balance and mobility of the participants. We adopted the BBS in the present study rather than the well-acknowledged Tinetti Balance and Gait Evaluation (Performance-Oriented Mobility Assessment [POMA])[29] because POMA is not suitable for analysis of slight differences, given the narrow range of scores in each item as previously suggested.[30]

The TUG test was designed as a quick measure of basic balance and mobility skill in elderly people. The time taken for subjects to rise from a chair, walk 3 m and return to the chair is measured in s, with a shorter time taken indicating better balance ability. Each subject was asked to perform two test trials. The mean score was recorded. The FR was designed to measure the limits of stability in an anterior direction. The score was determined by measuring the maximal distance that subjects can reach forward horizontally while maintaining a fixed base of support, with a greater distance indicating better balance ability. Two trials were performed and the mean score was recorded. The BBS was developed to measure balance impairments in elderly persons and people with neurological disorders. The scale consists of 14 common functional activities which are scored 0–4 (maximum score, 56). The MFS was created by totaling the scores for each item on the questionnaire, consisting of 14 items on motor fitness. This scale has a unidimensional structure with three subscales: mobility, strength and balance. In addition, all subjects were assessed on their postural sway, which was performed on a vertical force platform (Gravicorder GS-10 type C; ANIMA, Tokyo, Japan), fitted with three pressure gauges located in the corners. The subject was required to remain as stable as possible but relaxed, bipedal standing barefoot on the platform with the hands held hanging downwards in a neutral position, arms along the body and breathing normally, staring at a mark placed 2 m away, in a quiet room with artificial lightning. This test lasted 60 s and was performed with eyes open.

Evaluation of self-efficacy

Self-efficacy was evaluated using the Falls Efficacy Scale (FES).[31] The FES was designed to evaluate an individual's confidence in the ability to avoid a fall during each of 10 relatively non-hazardous ADL. The FES consists of questions related to the individual's concern about the possibility of falling when completing 10 specific daily living activities. Respondents are asked to identify, on a 10-point scale, how confident they feel of not falling when performing each activity, with 1 indicating extreme confidence and 10 indicating no confidence at all. The FES score was the sum of scores on each of the 10 activities. Possible scores range 10–100.

Measurement of muscle strength

The muscle strength in hip flexor, knee extensor, ankle extensor and flexor were measured using a hand-held dynamometer (EG-220; SAKAI, Tokyo, Japan) as the strength expressed in Newtons (N). No practice was

allowed before measurements except that oral instruction was given prior to the trials. Only one attempt providing verbal encouragement was made for both sides, and the mean of both sides was used for analysis in order to dilute the influence of the dominant side. None of the participants had history of medical conditions that may affect muscle strength such as overt osteoarthritis or stroke.

The maximum grip strength of the dominant hand was recorded with a Smedley's dynamometer (Matsuyoshi, Nagoya, Japan), expressed in kg. Participants were allowed to rest between the tests as necessary. Time to complete the interview and testing procedures ranged 40–60 min.

Falls record

Based on a definition of falls as "an unintentional change in body position resulting in contact with the ground or with another lower level, however, not as a result of a major intrinsic event (e.g. stroke, syncope) or an overwhelming hazard (e.g. car accident)",[32] history of incident falls and their frequency in a previous year was obtained from all participants. Also, they were given a "falls diary" and were asked to record fall events at the time they occurred during the 6-month follow-up period. The diary was collected at the end of the follow-up period for counting the number of falls subjected for analysis. All falls were recorded by the participants or their informants.

Statistics

Statistical analyses were performed using PASW (ver. 18.0) to investigate the association between the parameters examined and actual incidence of falls. Continuous variables between fallers and non-fallers were compared using the Mann–Whitney *U*-test.

Bivariate correlations on the cross-sectional data in both groups (fallers and non-fallers) were assessed using Spearman's rank of order correlation analysis to investigate the association between the functional scales and muscle strength.

Bivariate odds ratios (OR) with their 95% confidence intervals (CI) of the physiological variables at baseline were calculated for fallers who were defined as those who fell at least once or more during the 6-month observation period versus non-fallers who were defined as those who did not fall during the 6-month observation period.

Before constructing a multivariable model for the prediction of falls, univariate analysis was performed across all the variables. They were combined in a binary logistic stepwise regression analysis in which fallers and non-fallers formed a group criterion.

All the medical and pharmaceutical information were supplied by participants' attending geriatricians, and all the assessments were carried out by the same physiotherapist.

Results

The characteristics of the participants at baseline and the results of group comparison for continuous variables and of logistic univariate analysis are presented in Table 1. There were no statistically significant differences in all the continuous variables examined between fallers and non-fallers by Mann–Whitney *U*-test (Table 1).

Correlation analysis investigating associations between the scores of assessment scales and actual measurement of muscle strength and balance showed that there were significant correlations between handgrip strength and FES, FR, TUG, BBS, MFS and motor FIM in fallers and non-fallers. On the other hand, while significant correlations were found between muscle strength of hip flexor, knee extensor and cognitive FIM in non-fallers, it was muscle strength of the ankle dorsiflexor and plantar flexor that were significantly correlated with cognitive FIM in fallers (Table 2).

Because we only had a limited number of variables that gained *P*-values less than generally acceptable for the entrance to multiple logistic models, variables that met the increased threshold *P*-values ($P < 0.3$) in the univariate analysis, which were FES, mean of antero-posterior sway, BBS and handgrip strength, and those of our interest, which were age, muscle strength (hip flexor, knee extensor, ankle dorsiflexor and plantar flexor), functional measures (FR, TUG), ADL scales (motor FIM, cognitive FIM, BI) and sub-items of MFS, were forced into a binary logistic regression analysis (Table 3). A binary logistic stepwise regression analysis incorporating all the possible variables into the model revealed that only inability to "to go up and down the staircase" in MFS remained a significant variable to predict falls during the period of observation (Table 4).

Discussion

In the current study, we explored the factors of physical performances and self-claimed assessment scales related to actual incidence of falls in older female patients who were attending a geriatric outpatient clinic. Because all the participants of the present study were attending the clinic due to chronic medical conditions, which may have increased the risk of falls, the results obtained cannot necessarily be generalized to healthy community-dwelling older adults.

The analysis showed that the sub-item in MFS "being able to go up and down the staircase" has a possibility of

Table 1 Descriptive characteristics at baseline and logistic regression univariate analysis between fallers (F: $n = 25$) and non-fallers (NF: $n = 33$)

Category	Variable	All ($n = 58$) proportion (%) or mean ± SD	F ($n = 25$) proportion (%) or mean ± SD	NF ($n = 33$) proportion (%) or mean ± SD	*P*-value*	OR	95% CI	*P*-value
General	Previous falls (%)	65.5%	72.0%	60.6%	0.370 n.s.	1.67	0.55–5.11	0.37
	Falls (follow up) (%)	43.1%	100.0%	0.0%		–	–	–
	Age (years)	80.5 ± 5.7	80.5 ± 4.9	80.6 ± 6.3	0.795 n.s.	0.98	0.90–1.08	0.77
	Body mass index (BMI) (kg/m^2)	22.8 ± 4.0	22.5 ± 4.3	23.1 ± 3.8	0.451 n.s.	0.96	0.84–1.10	0.55
Medical	Polypharmacy (%)†	6.7 ± 3.5	6.8 ± 3.9	6.5 ± 3.2	0.906 n.s.	1.03	0.88–1.19	0.75
Psychological	Falls Efficacy Scale (FES) (range 1–100)	30.5 ± 20.7	35.1 ± 24.6	26.9 ± 16.7	0.303 n.s.	1.02	0.99–1.05	0.14
	Cognitive FIM	32.7 ± 3.0	32.3 ± 3.5	32.9 ± 2.6	0.604 n.s.	0.93	0.78–1.12	0.46
Postural	Length (cm)	133.3 ± 54.0	138.7 ± 69.9	129.4 ± 39.5	0.974 n.s.	1.00	0.99–1.01	0.52
	Mean of mediolateral direction sway (cm)	0.08 ± 1.5	0.27 ± 0.9	-0.06 ± 1.8	0.265 n.s.	1.17	0.81–1.70	0.41
	Mean of anteroposterior direction sway (cm)	−1.94 ± 3.1	−1.0 ± 3.9	−2.6 ± 2.2	0.078 n.s.	1.26	0.98–1.63	0.07
	Functional Reach test (FR) (cm)	18.5 ± 8.2	17.9 ± 8.2	19.0 ± 8.2	0.741 n.s.	0.98	0.92–1.04	0.60
	Berg Balance Scale (BBS) (score)	39.4 ± 9.2	37.9 ± 10.5	40.5 ± 8.1	0.566 n.s.	0.97	0.92–1.03	0.29
Physical	Handgrip strength (kg)	13.9 ± 4.9	13.0 ± 4.9	14.6 ± 4.9	0.278 n.s.	0.93	0.84–1.04	0.22
	Hip flexion strength (N)	17.4 ± 6.8	17.6 ± 6.4	17.3 ± 7.1	0.783 n.s.	1.01	0.93–1.09	0.84
	Knee extension strength (N)	9.6 ± 4.5	9.8 ± 4.1	9.5 ± 4.8	0.671 n.s.	1.02	0.90–1.14	0.79
	Ankle dorsiflexion strength (N)	19.6 ± 5.4	19.4 ± 4.5	19.7 ± 6.1	0.994 n.s.	0.99	0.90–1.09	0.84
	Ankle plantar flexion strength (N)	22.9 ± 14.7	21.7 ± 11.8	23.9 ± 16.7	0.962 n.s.	0.99	0.95–1.03	0.57
	Timed Up and Go test (TUG) (s)	15.3 ± 8.4	16.0 ± 7.1	14.7 ± 9.4	0.227 n.s.	1.02	0.96–1.08	0.58
	Motor Fitness Scale (MFS) (range 1–14)	5.8 ± 3.6	5.2 ± 3.8	6.2 ± 3.4	0.347 n.s.	0.93	0.80–1.08	0.32
ADL	Barthel Index (BI) (score 0–100)	93.9 ± 9.1	92.8 ± 10.7	94.8 ± 7.7	0.404 n.s.	0.98	0.92–1.03	0.41
	Motor FIM	84.3 ± 8.6	83.0 ± 9.7	85.4 ± 7.7	0.267 n.s.	0.97	0.91–1.03	0.33

*Difference of continuous variables between fallers (F) and non-fallers (NF) by Mann–Whitney *U*-test. †Polypharmacy is defined as a state of patients who were taking more than five medications. CI, confidence interval; n.s., non-significant; OR, odds ratio; SD, standard deviation.

Table 2 Correlation analysis between fallers (n = 25) vs non-fallers (n = 33)

	Fallers (n = 25)/Non-fallers (n = 33)				
	Handgrip strength	Hip flexor	Knee extensor	Ankle dorsiflexor	Ankle plantar flexor
Falls Efficacy Scale	−0.600**/−0.437*	−0.165/−0.169	−0.201/−0.054	−0.319/−0.091	−0.278/−0.107
Functional Reach test	0.596**/0.526**	−0.134/0.258	−0.070/0.191	0.049/0.132	0.255/0.234
Timed Up and Go test	−0.466*/−0.689**	−0.204/−0.136	−0.011/−0.085	−0.300/−0.095	−0.371/−0.202
Berg Balance Scale	0.398*/0.650**	0.147/0.326	0.105/0.228	0.192/0.272	0.248/0.323
Motor Fitness Scale	0.619**/0.690**	0.052/0.057	0.034/0.008	0.099/−0.033	0.186/0.015
Cognitive FIM	0.273/0.356	0.175/0.481**	−0.132/0.370*	0.443*/0.238	0.677**/0.360
Motor FIM	0.622**/0.416*	−0.013/0.304	0.090/0.113	0.199/0.153	0.290/0.232
Barthel Index	0.095/0.289	−0.077/0.100	0.135/0.088	0.108/−0.156	0.291/0.019

*$P < 0.05$ **$P < 0.01$. Correlations between muscle strength of lower extremities and assessment scales were examined using Spearman's coefficient of correlation. FIM, Functional Independence Measure.

being a significant ADL predictor of falls. This finding has clinical relevance, given that many older women with poor physical performance have difficulties in going up and down the staircase, and many falls in fact occur during such movement. It also has important implications for clinicians in view of planning effective rehabilitation for the prevention of falls. In usual clinical settings, on the other hand, clinicians can be advised that asking the simple question of whether the patient has any difficulty in using the staircase or observation of actual movement using a step under careful supervision may both be considered for the initial risk assessment of falls.

From our results, MFS can be recommended as the functional assessment of choice for physiotherapists working with older women. The scale is easy to administer, requires no special equipment and is equally applicable to any older adults. Appropriate falls risk assessment could also have important implications for secondary prevention strategies, where the role of professional guidance of a physiotherapist may be crucial. First, this can be used as a screening tool for the identification of older women at risk of falling. Second, it also provides the necessary information to construct an individualized physical intervention program as it examines general muscle strength, balance, mobility and coordination. We believe in the importance of an individualized rehabilitation program based on the assessment of various domains of physical function in order to identify individual risk of falls for effective interventions.

Training for independence in bathing and climbing stairs was reported to be the most difficult during rehabilitation of the elderly with apoplexy.[33] Nonetheless, the present findings suggest the importance of offering rehabilitation aimed at maintaining the ability of actual daily movement for preventing falls or deterioration in physical function.

As shown by our results concerning the postural sway control, inadequate anteroposterior stability may be an important predictor of falls, which is in agreement with the findings of Shumway-Cook *et al.*[34] Diminished muscle strength and low physical performance may enforce the impairment of postural reflexes and increase the risk of falls. The ability to perform ADL is related to balance and potential falls in older people.[35,36]

The postural sway control research by Nashner and colleagues explored muscle patterns that underlie movement strategies for balance.[37]

The ankle strategy is the first pattern for controlling upright sway to be identified.[37] Muscle activity begins in the distal muscle, the tibialis anterior, followed by activation of the quadriceps femoris and abdominal muscles. Use of the ankle strategy requires muscle strength in the ankles.

Table 3 Binary logistic regression analysis to predict risk model of fallers ($n = 25$) vs non-fallers ($n = 33$)

	B	SE	*P*-value	OR	95% CI
Age	0.098	0.103	0.341	1.103	0.902–1.349
FES	0.046	0.040	0.249	1.047	0.969–1.131
Handgrip strength	−0.172	0.178	0.334	0.842	0.594–1.193
Hip flexion strength	0.095	0.165	0.563	1.100	0.797–1.518
Knee extension strength	−0.200	0.244	0.413	0.819	0.507–1.321
Ankle dorsiflexion strength	0.045	0.163	0.783	1.046	0.760–1.440
Ankle plantar flexion strength	−0.050	0.047	0.283	0.951	0.868–1.042
FR	0.059	0.110	0.593	1.061	0.854–1.317
TUG	−0.063	0.082	0.440	0.939	0.800–1.102
Motor FIM	0.022	0.125	0.861	1.022	0.801–1.305
Cognitive FIM	−0.001	0.235	0.996	0.999	0.630–1.538
BBS	−0.171	0.136	0.209	0.843	0.646–1.101
BI	0.076	0.096	0.430	1.079	0.893–1.303
MFS: Being able to go up and down the staircase	3.169	1.746	0.069	23.795	0.777–728.628
No breathlessness when taking staircase	1.399	1.016	0.168	4.053	0.553–29.691
Being able to jump	0.381	1.548	0.805	1.464	0.070–30.435
Being able to run	−3.149	1.703	0.064	0.043	0.002–1.208
Being able to overtake others while walking	2.183	1.383	0.115	8.869	0.589–133.490
Being able to walk for more than 30 min without break	−1.086	1.045	0.299	0.337	0.044–2.617
Being able to carry a bucket filled with water	0.703	1.355	0.604	2.019	0.142–28.745
Being able to lift a 10 kg bag of rice	−3.459	1.723	0.045	0.031	0.001–0.921
Being able to stand a fallen bicycle up	1.371	1.164	0.239	3.941	0.402–38.603
Being able to open the lid of a jar	−0.875	1.099	0.426	0.417	0.048–3.591
Being able to touch the floor without bending the knees	−0.495	1.013	0.625	0.610	0.084–4.443
Being able to wear trousers, socks or skirts without support while standing	−3.115	1.586	0.050	0.044	0.002–0.994
Being able to rise from a chair without support of hands	0.814	1.246	0.514	2.257	0.196–25.949
Being able to stand on toes without support	−1.406	1.278	0.271	0.245	0.020–3.000
Constant	−0.910	16.988	0.957	0.402	

Sub-items of Motor Fitness Scale entered as dichotomous variable "yes" or "no". B, regression coefficient; BBS, Berg Balance Scale; BI, Barthel Index; CI, confidence interval; FES, Falls Efficacy Scale; FR, Functional Reach test; MFS, Motor Fitness Scale; OR, odds ratio; SE, standard error; TUG, Timed Up and Go test.

Table 4 Risk model for the prediction of fallers versus non-fallers obtained by binary logistic stepwise regression ($n = 58$)

	B	SE	*P*-value	OR	95% CI
Being able to go up and down the staircase	1.715	0.859	0.046	5.559	1.031–29.963
Constant	−2.178	1.013	0.032	0.113	

B, regression coefficient; CI, confidence interval; OR, odds ratio; SE, standard error.

The study has also identified another in-place strategy for controlling body sway, the hip movement strategy. This strategy controls motion at the hip joints with anti-phase of the ankles.[37]

Cognition is defined as the ability to process, sort, retrieve and manipulate information.[38] A normally functioning cognitive system is critical to successful interaction with the environment. Thus, impairments in this system affect the patient's ability to move effectively and efficiently.

In this study, there were significant correlations between cognitive FIM and muscle strength of the hip

flexor, knee extensor in non-fallers, which may imply that the hip strategy is used to restore equilibrium in response or perturbations when the support surface is smaller than the feet, making their muscles of hip and knee joints adjustable to sudden change of postures.

On the other hand, significant correlations were found between muscle strength of ankle dorsiflexor and plantar flexor and cognitive FIM in fallers.

This difference suggests that falls may tend to occur in those who are not capable of using the hip strategy for the initial perception of postural change.

As Daubney *et al.* tested, the ankle dorsiflexors were found to be the best predictor of falling.[39] During gait, the ankle dorsiflexors are involved, together with the hip and knee flexors, in lifting the lower limb during the swing phase to make sufficient clearance of the toes over the ground to prevent tripping. Taken together, lower extremity muscle strength may be an important predisposing factor in the pathogenesis of falls.

Going up and down the staircase is considered to depend mainly on functioning of the lower limbs, hence, the result that lower extremity muscle strength was not selected as significant variables in the logistic regression univariate analysis in the current study may be considered rather contradictory. A possible explanation as to why muscle strength in the lower extremities was not as predictive as handgrip strength might be found in the reliability of strength measures, which tend to be higher for handgrip strength than for leg strength when measured with a hand-held dynamometer, limiting somewhat the predictive value of leg muscle strength towards falling. Handgrip strength is correlated with muscle strength in the lower extremity,[40] and can therefore be a reliable measure of general muscle strength, as confirmed in a recent meta-analysis of prospective cohort studies.[41]

The relationship between reduction of muscle strength and difficulties in ADL may reflect an association with frailty and appears to be important in older women. When people withdraw from outdoor social contact, they become more susceptible to the negative effects of social isolation and physical inactivity.[17,42] The more activities that the older people avoid, the more difficulties they experience in doing these activities. Therefore, it is highly likely that avoidance of activities dramatically speeds up the process of physical frailty because of the devastating consequences of physical inactivity.[43] Avoidance of activities was not only related to the general status of physical frailty, but also to some specific components of physical function, including less muscle strength in the hip and knee, and less handgrip strength. Because the older people who avoid activities have decreased muscle strength, it is likely that they will experience limitations during activities such as shopping, going for a walk, walking around indoors and bending down to pick something up. This may further increase their feelings of insecurity and apprehension.

Maintenance of muscle strength throughout life reduces the prevalence of functional limitations that might closely relate to older persons.[44–47] It may also be expected to increase self-esteem and confidence in one's own abilities to perform physical activities, thereby avoiding social withdrawal. Increasing activity appears to be a simple and effective means of countering fall risk factors such as muscle weakness or functional limitations.

Limitations of the current study are as follows. First, there may be some uncertainties about the validity and reliability of self-reported falls even with a falls diary provided with sufficient instruction for use. The reliability of a fall questionnaire has been discussed by others,[48] and the discrepancy in this study confirms that there may be a recall bias. Therefore the variances in assessments may have affected the results. Second, the sample size was relatively small and the results shown in this study were obtained from a cross-sectional survey. The scale might perform differently in other populations. Longitudinal data are required to address this issue more carefully. Also, a longer period of intervention involving more participants would be warranted. Third, in the current study, subjects with significant depressive symptoms and those scoring lower than 15 on MMSE were excluded in order to endorse the reliability of a series of assessments and falls reports if they ever occurred. Although the physical performance in these subjects remains unknown, it is likely to substantially affect the outcomes if included. Lastly, lower extremity muscle strength was measured by a hand-held dynamometer, which may have resulted in inaccurate assessment of the muscle strength of the lower limbs in the current study. We assumed that the conflicting result we obtained in the present study might be due to a limitation other than small sample size and diverse background of the participants in that we used a hand-held dynamometer for measurements whose accuracy/test-retest reliability can possibly be questioned. The previous studies have reported some limitations of measuring muscle strength using a hand-held dynamometer as follows: consistency of the testing procedure,[49–51] patient effort,[50,52,53] degree of verbal inducements[51] and incentives.[49,53]

In conclusion, despite the limitations raised above, our findings indicate that a standard assessment of ADL may be a useful component in the risk assessment of falls in older women. The results confirmed that the sub-item in MFS has a possibility of being a significant predictor of falls in older women, therefore might prove useful in screening this population at risk of falls.

The results also permit further work investigating the individual effect of specific rehabilitation program on falls prevention in the older population.

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Depressive symptoms of informal caregivers are associated with those of community-dwelling dependent care recipients

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ABSTRACT

Background: The relationship between care recipients' depressive symptoms and those of caregivers remains unknown. We evaluated the association between the depressive status of caregivers and that of community-dwelling disabled care recipients.

Methods: A prospective cohort study of 893 care recipients and paired caregivers was conducted. The care recipients were all eligible for a universal-coverage long-term care insurance program and their ages ranged from 65 to 104 years. They and their paired caregivers (age range 31–90 years) completed the 15-item Geriatric Depression Scale (GDS-15, score range: 0–15) assessment at baseline. The GDS-15 was used to measure the depression of caregivers and recipients with a threshold of <6/6+. The data included each care recipient's demographic characteristics, overall health status, basic activities of daily living, and comorbidities. The data also included the caregiver's demographic characteristics, including the caregiver's relationship to the recipient, and the caregiver's subjective burden as assessed by the Japanese version of the Zarit Burden Interview (ZBI).

Results: The mean GDS-15 scores of care recipients and caregivers were 6.7 points and 5.6 points, respectively. There was a positive correlation between the GDS-15 scores of caregivers and care recipients ($r = 0.307$, $p<0.001$). Multivariate logistic regression analysis adjusting for potential confounders including ZBI score indicated that the depressive symptoms of caregivers were associated with those whose care recipients were in the groups with moderate and high GDS-15 scores (OR: 1.97, 95% CI: 1.39–2.81, OR: 3.13, 95% CI: 1.87–5.24, respectively).

Conclusion: Caregivers' depressive symptoms are associated with the depressive mood of the care recipients even after adjusting for confounders including caregiver burden.

Key words: depressive mood, caregiver burden, dependent frail older people

Introduction

The current trend toward a community-based health care system means that when older people require care, much of it will be provided at home. This trend will lead to family members providing care for ill or disabled older relatives. The majority of family caregivers are older spouses and middle-aged adult children who care for a spouse or a parent with functional limitations.

Longitudinal studies have demonstrated that being a caregiver who is experiencing mental or emotional strain is an independent risk factor for psychiatric morbidity in the form of increased depression, contributes to the risk of health problems, and is an independent risk factor for mortality (Kiecolt-Glaser *et al.*, 1995; Gallicchio *et al.*, 2002). Caregiver depressive symptoms indicate a mood disturbance that can result from the stress of providing care. A number of studies were conducted to identify the factors related to the depressive status of caregivers, and they found those factors to include the care recipient's dependency with regard to activities of daily living (ADL), dementia, and behavioral disturbance and the caregiver's the relationship to the patient (Farran *et al.*, 1997; Clyburn *et al.*, 2000; Covinsky *et al.*, 2003; McCusker *et al.*, 2007; Schulz *et al.*, 2008). Although it has been reported that caring depressed recipients is associated with poor mental health of caregivers including increased

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dissatisfaction and burden (Sewitch *et al.*, 2004; Soldato *et al.*, 2008), the relationship between care recipients' depressive symptoms and those of caregivers remains largely unknown. In the present study, we evaluated the association between depression in community-dwelling frail elderly and depression in their caregivers.

Methods

Cohort participants

In the present study we employed baseline data for the care recipient and caregiver pairs in the Nagoya Longitudinal Study for Frail Elderly (NLS-FE). Japan introduced a universal-coverage long-term care insurance (LTCI) program in 2000. Under the LTCI program, each applicant's care levels are determined according to eligibility criteria. Eligibility status is classified into six levels ("needs support" and care levels 1–5) via the estimation of care needs based on an assessment of the current physical and mental status of the patient and his or her use of medical procedures (Campbell and Ikegami, 2000; Tsutsui and Muramatsu, 2005).

The NLS-FE was designed to compare the outcomes of different uses of the community-based care services provided by the LTCI program (Kuzuya *et al.*, 2006a; 2006b). The study population consisted of 1875 community-dwelling frail elderly (632 men and 1243 women, age 65 years or older) with some degree of physical or mental disability who were eligible for the LTCI program and lived in Nagoya City, Japan. They received various kinds of community-based services from the Nagoya City Health Care Service Foundation for Older People, which has 17 visiting nursing stations associated with care-managing centers. These 1875 NLS-FE participants and 1502 caregivers (owing to the lack of a primary caregiver for 373 of the 1875 participants) were enrolled between 1 December 2003 and 31 January 2004. They were scheduled to undergo comprehensive in-home assessments by trained nurses at baseline and at 6, 12 and 24 months. At 3-month intervals, data were collected about any important events in the lives of the participants, including mortality, admission to hospital for acute illness, or institutionalization in long-term care facilities during the 3-year follow-up. Written informed consent for participation was obtained from the participants, care recipients and caregivers, or, for those with substantial cognitive impairment, from a surrogate (usually the closest relative or legal guardian) according to procedures approved by the institutional review board of Nagoya University Graduate School of Medicine.

Data collection

The data were collected at the clients' homes through standardized interviews with care recipients or their surrogates and caregivers, and from care-managing center records taken by trained nurses. The data included each participant's demographic characteristics, general socioeconomic status, living arrangements, use of medical services, and overall health or nutritional status. When the participants were unable to answer or had cognitive impairment, surrogates and caregivers were asked. The data also included depressive symptoms as assessed by the 15-item Geriatric Depression Scale (GDS-15) (range: 0–15, with higher values indicating more depressive symptoms) (Yesavage, 1997), the presence of behavioral disturbance in the care recipient according to the primary assessment dataset of the public LTCI, and a rating for ten basic activities of daily living (bADL) (feeding, mobility in bed, bathing, grooming, dressing, using the toilet, walking inside and outside, transferring, and using stairs) using summary scores ranging from 0 (total disability) to 20 (no disability). Information on the following physician-diagnosed chronic conditions was obtained from care-managing center records: cerebrovascular disease, dementia, hypertension, neurodegenerative disorders, and other diseases comprising the Charlson Comorbidity Index (Charlson *et al.*, 1987), which represents a sum of weighted indexes and takes into account the number and seriousness of pre-existing comorbid conditions (range: 0–19, with a higher value indicating higher comorbidity).

Data were also obtained from caregivers concerning their own personal demographic characteristics including the caregiver's relationship to the care recipient (spouse, adult child, daughter-in-law or other), depressive symptoms as assessed by the GDS-15, and the caregiver's subjective burden as assessed by the Japanese version of the Zarit Burden Interview (ZBI) (Arai *et al.*, 1997), which is a 22-item self-reported inventory that examines the burden associated with functional behavioral impairments in the home care situation (range: 0–88, with higher values indicating a greater burden).

Subjects for analysis

The study population consisted of 893 community-dwelling disabled elderly (337 men and 556 women, age range: 65–104 years) and paired caregivers (213 men, 680 women, age range: 31–90), made up of those who completed the GDS-15 assessment at baseline among the 1502 pairs. Of these 1502 care recipients, 389 could not complete the GDS-15 because of severe cognitive impairment or communication impairment. Among

the 1502 caregivers, 330 could not complete or refused to take part in the GDS-15. Compared with participants, 389 care recipients who could not complete the assessment had lower mean bADL scores (mean ± SD, 10.6 ± 7.5 vs 12.9 ± 5.9, $p < 0.001$), higher prevalence rate of behavioral problems (24.5% vs 15.1%, $p < 0.001$) and dementia (51.0% vs 30.5%, $p < 0.001$), Compared with participants, 330 caregivers who were excluded in the analysis were younger (mean ± SD, 63.1±12.4 vs 64.8 ± 12.6, $p = 0.003$) and had higher score o ZBI scores (mean ± SD, 31.3 ± 17.2 vs 28.0 ± 17.0, $p = 0.002$).

Statistical analysis

To evaluate the relationship between the GDS-15 scores of caregivers and those of care recipients, Spearman's rank correlation coefficient was used. Partial rank correlation coefficients adjusted for the age and gender of the care recipients and caregivers, the caregiver relationship to the care recipient (spouse or nonspouse), bADL scores and chronic diseases of the care recipients, and ZBI scores of the caregivers were also used to measure the relationships between the GDS-15 scores of the caregivers and care recipients. Student's t-test was used to determine differences in the GDS-15 scores of caregivers between those whose care recipients had chronic disease and those whose care recipients did not.

GDS-15 scores were categorized into three groups: 0–5 points (lowest), 6–10 points (modest), and ≥11 points (highest group). Comparing the Japanese version of the GDS-15 with a psychodiagnostic interview, a cut-off score of 6 yields the highest sensitivity and specificity (Wada *et al.*, 2004). Therefore, this cut-off was used in the present study. Univariate and multivariate logistic regression models were used to assess the independent predictors of the caregivers' depressive moods, defined as a GDS-15 score of 6 or higher. The following baseline data were used in univariate analysis: (i) the care recipients' data including gender, age, GDS-15 score, bADL score, presence or absence of behavioral problems and neurodegenerative disorders, and Charlson comorbidity index; (ii) the caregivers' data including gender, age, relation to care recipient (spouse or nonspouse (models 1 and 2); daughter-in-low, spouse, adult child or other (model 3)), and ZBI score. The covariates included in the multivariate analysis were variables associated with dependent variables where $p < 0.1$ in univariate analysis. The risk of a variable was expressed as an odds ratio (OR) with a corresponding 95% confidence interval (CI).

All analyses were performed using the Statistical Package for the Social Sciences (SPSS) Version 16.0. A probability value of 0.05 or less was considered significant.

Results

Characteristics of care recipients and caregivers

Table 1 shows the characteristics of the care recipients and caregivers. The mean age of the 893 care recipients was 80.4 years, with 31.4% of the total aged 85 years or older, and 62.3% were women. The mean GDS-15 score of the care recipients was 6.7 points, while 59.6% of the total had a score of 6 or higher, and 15.7% of the total had a score of 11 points or higher. Among the care recipients, 15.1% had behavioral problems, 36.9% had cerebrovascular disease and 30.5% showed dementia. The mean age of the caregivers was 64.8 years, and approximately 27% of the caregivers were 75 years or older. The caregivers were predominantly women and family members (45.4% were spouses). The mean GDS-15 score of the caregivers was 5.6 points, while 46.5% of the total had a score of 6 or higher and 12.5% had a score of 11 or higher.

As shown in Table 2, there were positive correlations between the bADL scores or ZBI scores of the caregivers, and both the GDS-15 scores of the care recipients and those of the caregivers. The ZBI scores of the caregivers were well correlated with the GDS-15 scores of both the care givers and recipients (Spearman's $\rho = 0.492$, $p < 0.001$; $r = 0.250$, $p < 0.001$, respectively). In addition, positive correlations were found between the caregivers' GDS-15 scores and the care recipients' GDS-15 scores (Spearman's $\rho = 0.307$, $p < 0.001$). The correlation between the GDS-15 scores of the caregivers and those of the recipients persisted after adjusting for potential confounders (partial rank correlation coefficient adjusted for the age and gender of care recipients and care givers, caregiver relationship to care recipient, bADL scores and neurodegenerative disorders of recipients, and caregiver's ZBI scores, $r = 0.207$, $p < 0.001$).

Caregivers providing care for recipients who exhibited behavioral problems or neurodegenerative diseases showed significantly higher GDS-15 scores compared with those providing care for recipients who did not exhibit such problems (mean (SD), behavioral problems: presence, 6.24 (3.68), absence, 5.45 (3.78), $p = 0.026$; neurodegenerative disorders: presence, 6.85 (3.69), absence, 5.49 (3.77), $p = 0.011$). However, there were no differences in the caregivers' GDS-15

Table 1. Baseline characteristics of the 893 care recipients and their caregivers

	CARE RECIPIENTS				CAREGIVERS			
	N	% OF TOTAL	MEAN	SD	N	% OF TOTAL	MEAN	SD
Men/women	337/556	(37.7/62.3)			213/680	(23.9/76.1)		
Age (years)			80.4	(7.6)			64.8	(12.6)
<65					391	(46.6)		
65–74	202	(22.6)			220	(26.2)		
75–84	411	(46.0)			198	(23.6)		
85+	280	(31.4)			30	(3.6)		
GDS-15 (range, 0–15)			6.7	(3.5)			5.6	(3.8)
0–5	361	(40.4)			478	(53.5)		
6–10	392	(43.9)			303	(33.9)		
11+	140	(15.7)			112	(12.5)		
Basic ADL (range, 0–20)	893		12.9	(5.9)				
Presence of behavioral problems	135	(15.1)						
Charlson comorbidity index (range, 0–19)			2.0	(1.6)				
Chronic diseases								
cerebrovascular disease	309	(36.9)						
dementia	272	(30.5)						
neurodegenerative disorders	53	(5.9)						
Relation to care recipient (% of total)								
spouse					405	(45.4)		
adult child					287	(32.1)		
daughter- in-law					169	(18.9)		
other					32	(3.6)		
ZBI (range, 0–88)					816		28.0	(17.0)

Table 2. Correlation coefficient between GDS-15 score of care recipient and that of caregiver

	CARE RECIPIENT'S GDS-15 SCORE	CAREGIVER'S GDS-15 SCORE
Care recipient's data		
Age	−0.033	−0.102*
GDS-15 score		0.307*
Basic ADL score	−0.173*	−0.140*
Caregiver's data		
Age	0.036	0.089*
ZBI score	0.250*	0.492*

*Correlation is significant at the 0.01 level (2-tailed).

scores between the absence and presence of cerebrovascular disease, dementia, or hypertension in the care recipients (data not shown).

To identify predictors of the depressive status of the caregiver (GDS-15 score $\geq$ 6), logistic regression analysis was conducted. Univariate analysis demonstrated that the depressive status of caregivers was associated with a GDS-15 score of the care recipients in the modest (6–10 points) or highest group ($\geq$11 points) (vs lowest group), higher bADL score, the presence of behavioral problems (vs absence), being an older caregiver, being the spouse of the care recipeint (vs nonspouse, or vs daughter-in-low), and higher ZBI score (Table 3). Multivariate analysis adjusting for the gender and age of the care recipients and caregivers, bADL scores, presence/absence of behavioral problems in the recipients, and caregiver relation to the recipient (model 1) indicated that the depressive status of the caregiver was associated with the care recipient having a GDS-15 score in the modest or highest group (OR: 2.26, 95%CI: 1.65–3.10, OR: 4.49, 95% CI: 2.85–7.05, respectively). When the analysis was adjusted for the variables used in model 1 plus the ZBI scores of the caregivers, these associations persisted between the depressive status of the caregiver and the depressive status of the care recipient (modest, OR: 1.97; 95% CI: 1.39–2.81; highest OR: 3.13, 95% CI: 1.87–5.24). In addition, these associations persisted when nonspouse caregivers were divided into 3 categories (daughter-in-law, adult child or other) (model 3 in Table 3).

Since the GDS-15 scale is used for the depressive symptoms for age 65 years or older, analysis involving caregivers $\geq$65 years (n = 448) was also conducted. Similarly, the depressive status of caregivers (GDS-15 score $\geq$ 6) was associated with a GDS-15 score of the care recipients in the modest or

Table 3. Logistic regression analysis to identify independent predictors of caregiver depressive symptoms (GDS-15>6)

	UNADJUSTED			MODEL 1			MODEL 2			MODEL 3		
BASELINE VARIABLES	OR*	95% CI	P	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
Care recipient's data												
Men (vs women)	0.73	0.56–1.00	0.230	0.77	0.52–1.14	0.190	0.88	0.56–1.38	0.579	1.08	0.69–1.70	0.746
Age (continuouss variable)	0.98	0.96–1.00	0.170	0.99	0.97–1.02	0.582	0.99	0.97–1.02	0.678	1.00	0.97–1.03	0.908
GDS-15 score (vs 0–5 points)	reference			reference			reference			reference		
6–10 points	2.15	1.60–2.89	<0.001	2.26	1.65–3.10	<0.001	1.97	1.39–2.81	<0.001	2.00	1.40–2.85	<0.001
≥11 points	5.04	3.29–7.71	<0.001	4.49	2.85–7.05	<0.001	3.13	1.87–5.24	<0.001	3.24	1.93–5.45	<0.001
Basic ADL (continuous variable)	0.96	0.94–0.98	0.001	0.98	0.95–1.00	0.071	1.01	0.98–1.03	0.733	1.00	0.98–1.04	0.638
Behavioral problems (vs absence)	1.59	1.10–2.30	0.014	1.49	1.00–2.23	0.053	0.83	0.52–1.31	0.416	0.83	0.52–1.32	0.424
Neurodegenerative disorders (vs absence)	1.31	0.75–2.29	0.340									
Caregiver's data												
Men (vs women)	0.76	0.56–1.04	0.083	0.73	0.49–1.08	0.113	0.76	0.49–1.18	0.222	1.25	0.79–1.97	0.343
Age (continuous variable)	1.01	1.00–1.02	0.032	1.00	0.98–1.02	0.904	1.00	0.98–1.02	1.000	1.00	0.97–0.97	0.623
Relation to care recipient												
nonspouse	reference			reference			reference					
spouse	1.57	1.20–2.04	0.001	1.19	0.68–2.08	0.543	1.34	0.70–2.57	0.380			
daughter- in-law	reference									reference		
spouse	1.78	1.23–2.56	0.002							2.14	0.96–4.78	0.065
adult child	1.15	0.78–1.70	0.482							1.49	0.91–2.44	0.118
other	1.94	0.90–4.21	0.092							2.49	0.89–6.93	0.081
ZBI score (continuous variable)	1.06	1.05–1.07	<0.001				1.06	1.05–1.07	<0.001	1.06	1.05–1.07	<0.001

*OR:Odds ratio
model 1 includes gender, age, caregiver's gender, caregiver's age, care recipient's GDS-15 scores, care recipient's bADL scores, care recipient's behavioral problems, caregiver relationship to care recipient (spouse).
model 2 includes model 1 and caregiver's ZBI scores.
model 3 includes caregiver's relation to care recipient instead of nonspouse in model 2.
Listed variables were care recipient/caregiver gender and age, the presence/absence of neurodegenerative disorders, and those associated with caregiver depressive status with $p<0.1$ in univariate analysis. The presence/absence of neurodegenerative disorders was listed because of the significant higher GDS-15 score of caregiver with recipients who exhibited neurodegenerative disorders.

highest group (vs lowest group): univariate analysis, OR: 2.07, 95%CI: 1.36–3.16 or OR: 4.07, 95%CI: 2.28–7.27, respectively; multivariate model 1, OR: 2.05; 95% CI: 1.33–3.15 or OR:3.95, 95% CI: 2.17–7.20, respectively; multivariate model 2, OR: 1.76; 95% CI: 1.09–2.83 or OR:2.71, 95% CI: 1.38–5.34, respectively).

Discussion

In the present study we observed a relatively high prevalence of depressive mood, not only in community-dwelling care recipients but also in their caregivers. We also demonstrated that the caregiver's depressive symptoms are associated with the depressive mood of the care recipient even after adjusting for confounders.

It has been shown that 8–16% of the general elderly population have clinically significant depressive symptoms (NIH Consensus Development Conference, 1992; Blazer, 2003). We observed a much higher prevalence of depressive symptoms among care recipients and caregivers (59.6% and 46.4%, respectively), a finding that is consistent with previous studies showing that late-life depressive symptoms often arise in the context of medical and neurological disorders including dementia, poor physical health, and disability (Alexopoulos, 2005). In addition, it has been demonstrated in a finding that is consistent with our results that caregivers of elderly disabled individuals are twice as likely as non-caregivers to develop symptoms of depression (Baumgarten *et al.*, 1992; Alexopoulos, 2004).

Previous studies demonstrated that the predisposing factors of caregiver depression include a care recipient with behavioral problems (Clyburn *et al.*, 2000), being a male caregiver, being an older caregiver, being a spouse caregiver (Farran *et al.*, 1997), and higher ADL dependency (Covinsky *et al.*, 2003). In agreement with previous reports, we observed that caregiver depressive symptoms were associated with the presence of behavioral problems, poorer ADL status of the recipient, being an older caregiver, and being a spouse caregiver (in univariate analysis). However, after adjusting for confounders the association between these factors and caregiver's depressive symptoms disappeared. On the other hand, multivariate logistic models revealed that depressive symptoms in the caregiver (GDS-15 $\geq$ 6) were associated with the caregiver's burden and the presence of depressive symptoms in the care recipient.

It has been reported that depressive symptoms in older people are independently associated with significantly higher levels of informal caregiving (i.e. caregiving that was needed for a longer time) (Langa *et al.*, 2004; McCusker *et al.*, 2009), and that caring for elderly depressed family members was associated with caregiver burden, poor caregivers' quality of life, and poor mental health in informal caregivers (Sewitch *et al.*, 2004; Soldato *et al.*, 2008). In fact, in the present study we observed that the ZBI scores of caregivers were well correlated with the GDS-15 scores of care recipients. It is possible that depressed patients (care recipients) may require more help in performing everyday basic tasks, including basic and instrumental ADL, than non-depressed patients (Penninx *et al.*, 2000), therefore increasing the caregiver burden. In the present study we have clearly demonstrated that the caregiver's GDS-15 score was well correlated with the GDS-15 score of the care recipient, even after adjusting for confounders. Furthermore, caregiver depressive symptoms were associated with care recipient depressive symptoms in univariate analysis. It is possible that this association was mediated though caregiver burden, since caregiver burden may be a predictor of depression in the caregiver (Raveis *et al.*, 1998; Clyburn *et al.*, 2000; Sherwood *et al.*, 2005). The OR of depressive symptoms of the care recipient for caregiver depressive symptoms decreased after adjusting for ZBI score, but still reached statistical significance, suggesting that caregiver burden may contribute to caregiver depressive symptoms at least in part, but that caregiver burden may not be a major mediator of the association between caregiver and recipient depressive symptoms. It is also possible that being a caregiver can produce psychological benefits including an enhanced caregiver–care recipient relationship (Amirkhanyan and Wolf, 2003). The caregivers of patients with depression may lack this kind of reward. However, depression in the care recipient could also be a consequence rather than a cause of caregiver depressive symptoms.

The present study has several limitations. First, cross-sectional data can reveal associations but cannot be used to delineate whether caregiver depressive symptoms are a cause or result of the depressive status of the care recipient. To examine the causality of the association between the depressive symptoms of caregivers and those of recipients, further study is required. Second, the results of the present study cannot be applied to independent community-dwelling older individuals, since there are many differences between the participants of NLS-FE and independent older people, including differences in ADL levels and comorbidity. Finally, these findings may not be generalizable to other populations given that they may have been influenced by cultural differences, health practices, and a variety of social and

economic factors. These findings need to be confirmed in longitudinal studies in the future.

It should be noted that although GDS-15 is frequently used for subjects under 65 years old, it is also used for the measurement of depression in older people (Covinsky *et al.*, 2003; Molyneux *et al.*, 2008). When analysis involving caregivers aged ≥65 years was conducted, similar results were observed as described here.

The present study shows that there is an association between depression in caregivers and the depressive symptoms of their care recipients. Clinicians and policy-makers should recognize the potential increase in depressive mood in caregivers who care for dependent older people with depressive symptoms. Clinicians should inquire about the adequacy of social support for their older patients with depressive symptoms and should also be alert to potential caregiver depression among family members who provide care.

Conflict of interest

None.

Description of authors' roles

S. Izawa analyzed the data and wrote the paper. J. Hasegawa conducted the study and interpreted data. H. Enoki analyzed and interpreted data. A. Iguchi assisted with the concept. M. Kuzuya supervised all authors involved and edited the paper.

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FACTORS ASSOCIATED WITH NONADHERENCE TO MEDICATION IN COMMUNITY-DWELLING DISABLED OLDER ADULTS IN JAPAN

To the Editor: Nonadherence to drug therapy is a serious problem for older people, because adherence to medication is essential for obtaining the optimal therapeutic effects of medication.[1–4] Although numerous studies have identified the factors related to nonadherence to drug therapy, only limited studies have taken a wider perspective, focusing on adherence in older community-dwelling disabled adults and on factors affecting adherence.[5,6] The aim of this study was to identify the factors associated with nonadherence to drug therapy in older community-dwelling disabled adults.

The present study used baseline data on participants in the Nagoya Longitudinal Study for Frail Elderly.[4,7,8] The study population consisted of 1,722 older community-dwelling disabled adults (611 men, 1,161 women; mean age 80.3 ± 7.6, range 65–104) and 1,502 caregivers (375 men, 1127 women; mean age 64.1 ± 12.6, range 31–93). The baseline data included the recipients' demographic characteristics, activities of daily living (ADLs), depressive symptoms as assessed using the short version of the Geriatric Depression Scale (GDS-15), physician-diagnosed chronic conditions, living arrangement, number of prescribed medications, and self-reported difficulty with self-medication management, which was assessed as previously described.[4] The participants or family were also asked whether they were receiving any assistance for taking medication or medication management from others. The participants were divided into two groups: no difficulty with self-medication management, and difficulty with self-medication management. Data were also obtained from caregivers concerning their own personal demographic characteristics, their subjective health status, and burden as assessed according to the Zarit Burden Interview. The adherence rate to the prescribed medication was defined as the total number of pills taken divided by the total number of prescribed pills as assessed by the self-reported average medication adherence during 1 month. It was decided to use self-reporting rather than other forms of adherence measurements because they are prohibitively expensive and cumbersome, and there is little evidence that they are superior to self-report instruments.[1,9] Nonadherence was defined as less than 80% of the adherence rate. Univariate and multivariate logistic regression were used to determine which characteristics of the disabled older adult or caregiver predicted nonadherence to prescribed medication.

Of 1,772 participants, 223 (12.6%) were categorized as nonadherent. Univariate logistic analysis demonstrated that participants living alone (vs living with someone, odds ratio (OR) = 1.43, 95% confidence interval (CI) = 1.04–1.96), with depression (GDS-15 $\geq$ 11 vs $<$5, OR = 1.61, 95% CI = 1.03–2.53), and with dementia (vs its absence, OR = 1.47, 95% CI = 1.10–1.96) and participants who had difficulty with self-medication management (vs no difficulty with self-medication, OR = 1.69, 95% CI = 1.24–2.30) were more likely to be nonadherent. Multivariate analysis (Table 1, Model 1) showed that medication nonadherence was associated with participants living alone, having depression, and having difficulty with self-medication. When participants who had difficulty with self-medication were divided as to the absence or presence of assistance (Model 2), nonadherence was associated with participants living alone, participants with depression, the presence of dementia, participants who had difficulty with self-medication but had no assistance, and participants with assistance. For participants who had difficulty with self-medication and had assistance, none of the variables of care recipients were associated with nonadherence in univariate analysis. Multivariate analysis revealed that a male caregiver and poor subjective health status of the caregiver were likely to result in nonadherence in participants having assistance.

In the present study, it was observed that participants who had difficulty with self-medication management had a high risk of nonadherence to medication. In particular, participants needing support but who did not have any, had a OR of nonadherence 3.2 times as high as those who had no difficulty with self-medication management, suggesting that medication management assessment is needed to determine which older people are at risk of medication management problems and to minimize adverse events attributable to poor medication adherence. Participants receiving medication management assistance had an OR of medication nonadherence 1.64 times as high as participants who had no difficulty with self-medication management. These results may imply that families or relatives living with disabled older patients may not always give appropriate assistance for medication management. A male caregiver and subjective poor health status of the caregiver were associated with recipient nonadherence to prescribed medication, suggesting that caregivers with those characteristics may tend to provide inadequate levels of assistance for medication or that neglectful behavior by caregivers may be involved in this association.

In conclusion, the results suggest that, in older community-dwelling disabled adults, the lack of medication assistance for those needing medication support was associated with a higher risk of nonadherence, although even those receiving assistance had a higher risk of nonadherence than those with no difficulty with self-medication management.

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Table 1. Logistic Regression Analysis for Nonadherence

Characteristic	Odds Ratio (95% Confidence Interval)		
	Multivariate*		
	Model 1†	Model 2‡	Multivariate for Those Having Assistance§
Care recipient characteristics			
Men (vs women)	0.86 (0.61–1.23)	0.89 (0.62–1.28)	—
Age (continuous variable)	0.99 (0.97–1.02)	0.99 (0.97–1.02)	—
Living alone (vs living with someone)	2.00 (1.35–2.95)	1.94 (1.31–2.86)	1.38 (0.59–3.25)
GDS-15 (range 0–15) (vs score 0–5)			
6–10	1.22 (0.85–1.77)	1.25 (0.86–1.81)	—
≥ 11	1.61 (1.02–2.53)	1.68 (1.06–2.66)	—
Presence of dementia (vs absence)	1.34 (0.91–1.97)	1.56 (1.04–2.36)	—
Medication management (vs self medication)			
Difficulty with self-medication	2.04 (1.37–3.05)	—	—
Absence of assistance	—	3.20 (1.92–5.34)	—
Presence of assistance	—	1.64 (1.05–2.54)	—
Caregiver characteristics			
Men (vs women)	—	—	1.90 (1.18–3.06)
Age (continuous variable)	—	—	1.00 (0.98–1.02)
Subjective health status (vs good to excellent)			
Fair	—	—	0.90 (0.54–1.49)
Poor	—	—	2.09 (1.11–3.94)

*The covariates included in the multivariate analysis were variables associated with nonadherence with $P<.05$ in univariate analysis. Activity of daily living score, presence of comorbid diseases (ischemic heart disease, congestive heart failure, cerebrovascular disease, diabetes mellitus, cancer, or hypertension), number of medication, and regular medical examination were not associated with nonadherence in univariate analysis. All analyses were performed using SPSS version 17.0 (SPSS, Inc., Chicago, IL).

†Model 1 includes sex, age, living alone (vs living with someone), 15-item Geriatric Depression Scale (GDS-15) categories, presence of dementia (vs absence), and difficulty with self-medication (vs no difficulty).

‡Model 2 includes sex, age, living alone (vs living with someone), GDS-15 categories, presence of dementia (vs absence), and absence or presence of medication assistance (vs no difficulty).

§Logistic regression analysis was conducted to identify the predictor of the risk of nonadherence in 929 participants who had difficulty with self-medication and had assistance. The covariates included in the multivariate analysis were variables associated with nonadherence with $P<.05$ in univariate analysis. None of the variables of care recipients, including sex, age, comorbidity, depressive status, and number of prescribed medications, were associated with nonadherence in univariate analysis. The relationship to care recipient (spouse vs nonspouse) and the Zarit Burden Interview score were not associated with nonadherence in univariate analysis.

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Author Contributions: Masafumi Kuzuya: study concept, design, conduct of study, interpretation of data, study supervision, and preparation of manuscript. Hiromi Enok: and Sachiko Izawa: analysis and interpretation of data. Jun Hasegawa and Yusuke Suzuki: conduct of study and interpretation of data. Akihisa Iguchi: study supervision.

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