Table 1 Background characteristics of participants by age

	80–89 years old Total	Male	Female	90–99 years old Total	Male	Female	≥100 years old Total	Male	Female
Characteristics									
No. of participants (%)	56[††]	28 (50.0)	28 (50.0)	48[††]	12 (25.0)	36 (75.0)	56[††]	10 (19.6)	46 (80.4)
Age, mean ± SD	83.7 ± 2.2	83.3 ± 2.0	84.1 ± 2.4	92.4 ± 2.2	92.6 ± 2.4	92.3 ± 2.2	102.0 ± 1.3	101.7 ± 1.3	102.0 ± 1.4
Age, range	80–89	80–89	80–89	90–99	90–98	90–99	100–107	100–103	100–107
Living arrangements, *n* (missing)	56	28	28	46 (2)	12	34 (2)	56	10	46
Alone (%)	7 (12.5)	2 (7.1)	5 (17.9)	3 (6.25)	1 (8.3)	2 (5.6)	1 (1.8)	0 (0.0)	1 (2.1)
With family (%)	46 (82.1)	25 (89.3)	21 (75.0)	32 (66.7)	9 (75.0)	23 (63.9)	41 (73.2)	8 (80.0)	33 (71.7)
With spouse	16	13	3	7	6	1	0	0	0
With biological child	15	9	6	14	2	12	26	6	20
Multigenerational housing 1	14	3	11	9	1	8	9	1	8
Multigenerational housing 2	1	0	1	2	0	2	6	1	5
Institution (%)	3 (5.3)	1 (3.6)	2 (7.1)	13 (27.1)	2 (16.7)	9 (25.0)	14 (25.0)	2 (20.0)	12 (26.1)
Functional ability, *n* (missing)	52 (6)	27 (1)	25 (3)	47 (1)	11 (1)	36	55 (1)	10	45 (1)
Barthel Index, mean ± SD	86.7 ± 27.0[†]	77.1 ± 30.9	88.7 ± 21.2	63.5 ± 31.2[†]	91.8 ± 15.2[‡]	54.9 ± 29.7[‡]	44.2 ± 33.9[†]	48.5 ± 39.4	43.3 ± 33.0
Independent A % (100)	53.8	44.4	64.0	23.4	72.7	8.2	7.3	18.2	4.6
Independent B % (80–99)	15.4	18.5	12.0	12.8	9.1	13.9	16.4	27.3	13.6
Minimal help % (60–79)	15.4	14.8	16.0	27.7	18.2	30.6	18.2	0.0	22.7
Partially dependent % (40–59)	3.9	7.4	0.0	10.6	0.0	13.9	9.1	0.0	11.4
Very dependent % (20–39)	7.7	7.4	8.0	19.1	0.0	25.0	18.2	27.3	15.9
Totally dependent % (<20)	3.9	7.4	0.0	6.4	0.0	8.3	30.9	27.3	31.8
Lawton and Brody IADL, mean ± SD[§]		3.5 ± 1.7	5.8 ± 3.0		4.0 ± 1.2	1.6 ± 1.7		1.3 ± 1.6	1.3 ± 1.9
Smoking status, *n* (missing)[¶**]	52 (4)	28	24 (4)	46 (2)	12	34 (2)	55 (1)	10	45 (1)
Current smoker	7	6	1	1	1	0	0	0	0
Ex-smoker	16	14	2	7	6	1	7	5	2
Never smoker	29	8	21	38	5	33	48	5	43

[†]For total Barthel Index (BI) scores, $P < 0.001$. [‡]For male vs female mean BI scores, $P < 0.0001$. [§]Male and female total instrumental activities of daily living (IADL) scores by age groups, $P < 0.001$. [¶]Gender differences in smoking status by age, $P < 0.001$. **For smoking status by age, $P < 0.0001$. [††]Proportion of females increases by age, $P < 0.0001$. SD, standard deviation.

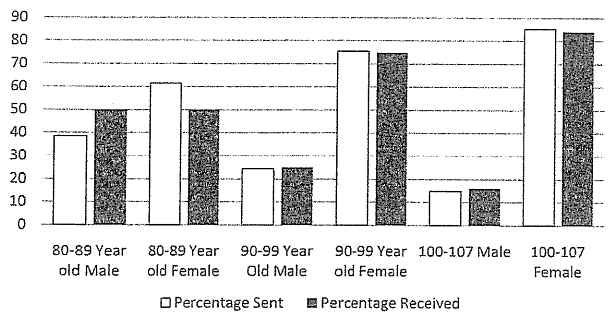


Figure 1 Response rates by age and sex. Open bars denote percentage of questionnaires sent by age and sex groups. A total of 405 questionnaires were sent, 135 to each age group of 80–89, 90–99, and 100–107 year olds. Closed bars denote the percentage of questionnaires received by age and sex groups. A total of 160 questionnaires including 56, 48 and 56 questionnaires by 80–89, 90–99 and 100–107 year olds, respectively, were received.

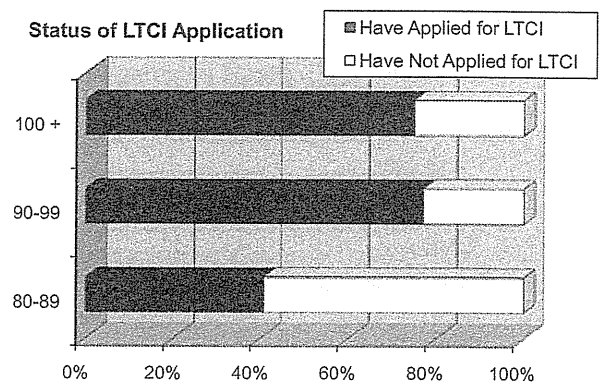
disorders, osteoporosis, breast cancer and depression at the time of the questionnaire. Other respondents reported past histories of stroke, lung disease, breast cancer and heart attacks. In contrast, a small number of respondents reported continued independence, wellness, and freedom from major illnesses and dementia. Some centenarians reported continuing driving, shopping, sightseeing and attending university classes.

Less than 25% of centenarians in this study reported care beginning before the age of 92 years while 12.1% began receiving care after their 100th birthday (mean age when care began 95.0 ± 5.5 years). Over 75% of centenarians reported receiving care for less than 10 years, the shortest being 11 months and the longest being over 23 years.

Most centenarians (75%) lived in their own private home. Among community-dwelling elderly, 97.6% (41/42) of centenarians lived in family and multigenerational households. The prevalence of third generational families, which include children, grandchildren and great grandchildren, increased with the age of the care respondent. Second generational families, which included children and grandchildren, were more prevalent than third generational families in homes containing a centenarian. One centenarian lived independently and no centenarians had a living spouse. The rates of institutionalization increased with respondent age ($P < 0.001$) though the ratio of institutionalized to community-dwelling centenarians is slightly less than 90–99 year olds.

An application for LTCI had been made by 75% of centenarians (42/56) compared to less than 57% of controls (Fig. 2a). Two of the 42 centenarians who applied for LTCI did not qualify to receive assistance. A total of 16 centenarians (28.6%), 10 whom lived with their biological children, did not have a LTCI support or care needs level.

(a)



(b)

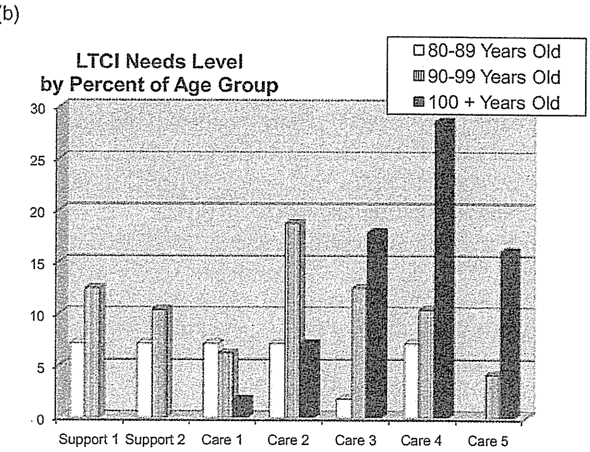


Figure 2 Status of Long-Term Care Insurance (LTCI) by age. (a) Status of applications for LTCI. Open bars show individuals who had not applied for LTCI while closed bars show individuals who had applied for LTCI. Respondents were 80–89 ($n = 54$), 90–99 ($n = 48$) and 100–107 years old ($n = 56$). (b) Percentage of respondents by age group who were eligible for LTCI according to their LTCI care needs level. Open bars represent 80–89-year-old respondents ($n = 13$), closed bars represent 90–99-year-old respondents ($n = 25$), and striped bars represent 100–107-year-old respondents ($n = 40$). Care needs levels range from Support 1, those who are eligible to receive the least amount of services, to Care 5, those who are eligible to receive the maximum amount of services.

The number of respondents who qualified to receive a LTCI support or care needs level increased with age among control recipients ($P < 0.005$) (Fig. 2b). More than 71% of centenarians qualified for LTCI compared to less than 38% of 80–89 year olds who received a support or care needs level and were eligible to utilize LTCI assistance ($P < 0.001$). Centenarians were five times more likely to receive higher care level numbers than 80–89-year-old recipients and three times more likely than 90–99-year-old recipients.

Centenarians were more likely to receive care regularly and to receive LTCI services ($P < 0.001$). Over 73% of centenarians received care regularly. Of the 70% of centenarians (39/56) who reported receiving insurance services, 20.5% (8/39) also received private services. Forty percent more centenarians used LTCI services than 80–89 year olds.

Care needs level beneficiaries receiving care regularly significantly correlated with an increase in recipient age from 52% of 80–89 year olds to over 90% of centenarians ($P < 0.001$). More than 87% of centenarians with LTCI care needs levels receive LTCI services compared to 71.4% of 80–89 and 66.6% of 90–99-year-old controls ($P < 0.004$).

Over 58% of centenarians reported receiving informal care compared to 35.6% of controls ($P < 0.001$). Those receiving informal care were more likely to also receive LTCI services ($P < 0.001$), private services ($P < 0.01$) and care regularly ($P < 0.001$) than those who did not receive informal care. Fewer Independent centenarians (30.7%) reported receiving informal care compared to over 74% of Dependent centenarians ($P < 0.001$).

Centenarians reported receiving 15 different formal services (Fig. 3a) and 17 informal services (Fig. 3b). LTCI services were primarily focused on ADL (41%) followed by medical (37%) and IADL (22%). Informal services focused mainly on IADL (57%) followed by ADL (39%) and medical (4%).

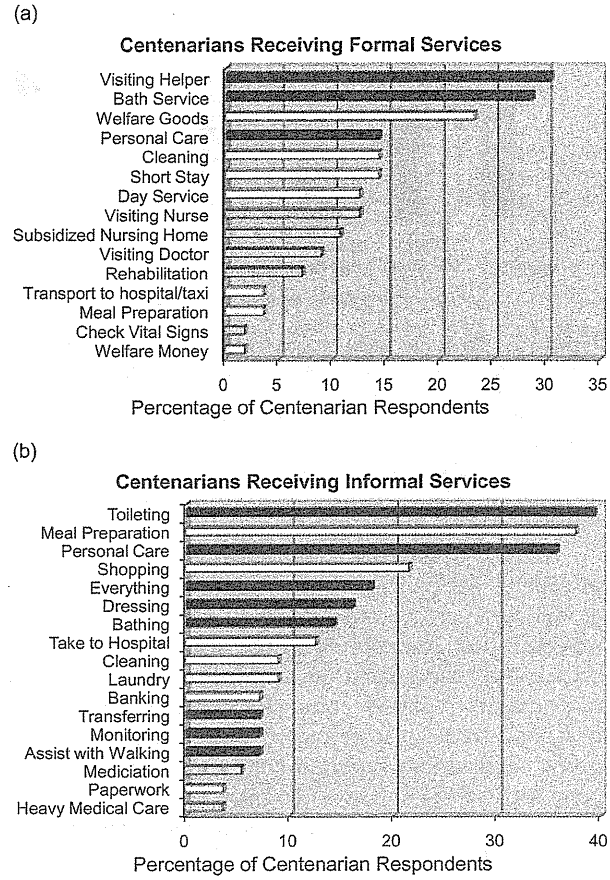


Figure 3 Percentage of centenarians who utilize various formal and informal services. (a) Percentage of indicated formal services including services subsidized by LTCI and privately paid services. (b) Percentage of centenarians receiving the indicated informal services. For both (a) and (b), categories of activities of daily living (ADL) services are denoted by closed bars, categories of instrumental activities of daily living (IADL) services denoted by open bars include day service (senior day care centers which provide various activities ranging from recreation and social activities for individuals with high ADL functioning to rehabilitation and bathing for individuals with lower ADL functioning), receive welfare goods (which include provision of subsidized care equipment such as automatic beds, raised toilet seats, wheelchairs, walkers and hand rails), short stay (which are limited duration programs which include overnight accommodation at a facility, primarily designed for caregiver relief, where the individual returns to their private home after a short period) and paperwork (paperwork related to coordination and payment of care services), and medically oriented services shown in vertically striped bars include subsidized nursing home (LTCI provides some money for institutional fees) and heavy medical care (tube drainage and tube feeding). Percentages of centenarian users are shown.

Discussion

Centenarians in the current study represent a diverse group of individuals ranging from functionally independent to completely dependent and comatose supporting previous research by Evert *et al.*[8] who categorized centenarians into three groups: delayers, escapers and survivors. Some centenarians in this study reported continuing to function autonomously suggesting possible escape from age-associated illnesses which would have limited their ability to continue IADL and supporting previous findings that dementia in centenarians is not inevitable.[9] Individuals who began receiving care after 92 years may have delayed the onset of age-associated illnesses supporting the compression of morbidity hypothesis[10] while others who live with various diseases or disorders may be survivors. Three centenarians reported receiving care for over 20 years, further suggesting the existence of centenarians who survive to advanced age while suffering from disease.

Male 90–99 year olds exhibited higher functional abilities than 80–89 year old and centenarian respondents suggesting that males who live longer are physically healthier than their female counterparts. This supports the gender cross-over phenomenon described by Ohrui *et al.*[11] suggesting that physically weaker males died at younger ages and only the physically strongest males are able to survive to advanced old age while females continue to survive with more physical impairments. The gender cross-over effect in this study peaks in 90–99 year olds and is greatly reduced among centenarians. Although centenarian males comprise the minority of centenarians, they continue to have higher BI and IADL scores than females. Interpretations of gender cross-over are limited, however, due to the small sample size of males aged 90–99 years old.

This study suggests, but due to the limited size of 90–99 year old males is unable to confirm, previous findings by Perls[12] that male centenarians tend to be better off than female centenarians in terms of physical functioning and that females seem to be physiologically stronger in old age and more likely than males to be able to live with chronic illnesses and disabilities.

While other studies have focused upon centenarians gathered on a certain date,[13] this was impossible in the present study due to the subject demographic collection methods in Japan. The principal investigator S. F. obtained centenarian and control subject data by manually searching over 1 million names printed in city registrar books stored at seven local city offices. This process took 3 months during which the registrar books were not updated.

In this study, two centenarians failed to qualify for LTCI services. By denying LTCI certification it is implied that the individual has high physical and mental abilities. However, the BI level of one of the centenarians denied certification is partially dependent and may suggest misevaluation. It is vital that measurement tools for LTCI eligibility be adjusted to effectively evaluate the centenarian population.

Multigenerational households are more prominent in Japan than other industrialized countries. In Japan, 8.5% of households are multigenerational[14] in contrast to 3% in Great Britain.[15] Multigenerational households may affect the lower levels of institutionalization found in this study as nearly 10% of centenarians in this study live in multigenerational housing. The New England Study found 27% of centenarians lived with family[16] compared to over 71% in this study. Sendai City reports a high proportion of family and multigenerational housing suggesting continuation of traditional cultural practices of aging parents living with their children. Although the rate of institutionalized Japanese centenarians in this study is much less than the 61% found in the New England study, only one centenarian reported living alone compared to 12% in the USA.[16] Low levels of institutionalization reported in this survey may also be affected by the inability of institutionalized care recipients to provide informed consent or refusal by families to report the institutionalization of a family member. In Japan, when a family member enters an institution it is common to keep the registered address as a private residential address and not to change it to an institutional address to avoid social stigmas and therefore it is possible that some of the questionnaires did not reach the elderly person due to incorrect addresses.

The recruitment of centenarians can be extremely difficult. In a study by Hirose *et al.*, of the approximately 1800 centenarians available for study, only 273 agreed to participate, representing a sample size of 15.2%.[17] Moreover, in a study by Shimizu *et al.*, only 22% of the total centenarians in Tokyo were included for study.[18] In contrast, this study reports a centenarian participation rate in Sendai City of 41.5%, double that of Shimizu *et al.*, and more than three times that of Hirose *et al.*[17,18]

The overall participation rate was expected due to multiple unavoidable factors including; high centenarian mortality rate, cognitively impaired individuals inability to provide informed consent, questionnaire length and the slow updating of city registrars.

Although every effort was made to minimize selection bias, it may be unavoidable due to methodological limitations of the questionnaire study protocol. Permission for this study from the Japanese Ministry of Justice and from Sendai City Office permitted only a one-time questionnaire and introduction letter to be sent to selected participants. The researchers were prohibited from contacting respondents by phone, in person visit or follow-up correspondence due to restrictions under Japanese law.

Data gathered may be limited in size and by response rate, however, these are an invaluable resource as this is the first study to provide insight into the situation of centenarians in northern Japan and is an excellent opportunity to increase understanding of how the oldest old utilize the new LTCI program.

In conclusion, centenarians represent a diverse group of individuals with distinctive needs. Centenarians can be classified into various groups suggesting numerous paths to attaining longevity. Gender cross-over, most prevalent among 90–99 year olds, decreased among centenarians. It is possible individuals have been misevaluated under the LTCI program and investigation is needed to determine if the LTCI system effectively assesses centenarians. This is the first in-depth look into the actual situation of community-dwelling oldest old in northern Japan examining functional ability and care service utilization.

By increasing understanding of the health needs of centenarians, government officials can target future health-care services to prepare for the increasing demands from this growing population. Future investigation of centenarians should focus upon the reasons for applying or not applying to LTCI, medical history, family and genetic profiles, and satisfaction with the health-care system.

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ORIGINAL ARTICLE: BEHAVIORAL AND SOCIAL SCIENCES

Physical and functional factors in activities of daily living that predict falls in community-dwelling older women

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Aim: 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 the physical and functional factors related to actual incidence of falls.

Methods: Fifty-eight female patients aged 65 years and older (mean age ± standard deviation, 80.5 ± 5.7), who were attending a geriatric outpatient clinic participated. All the participants were assessed with their activities of daily living, gait and balance using various scales. Their handgrip strength and muscle strength of lower extremities were also measured using dynamometers. Falls of the participants during the 6 months follow-up period were recorded.

Results: 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 Falls Efficacy Scale, Functional Reach test, Timed Up and Go test, Berg Balance Scale, Motor Fitness Scale, motor Functional Independence Measure in fallers and non-fallers. A binary logistic stepwise regression analysis incorporating all the possible variables into the model revealed that only inability to "being able to go up and down the staircase" in the Motor Fitness Scale remained a significant variable to predict falls during the period of observation.

Conclusion: The results confirmed that the sub-item in the Motor Fitness Scale has a possibility of being a significant predictor of falls in older women, and therefore might prove useful in considering specific rehabilitation program on falls prevention as well as screening this population at risk of falls. **Geriatr Gerontol Int 2011; 11: 348–357.**

Keywords: activities of daily living, incidence of falls, physical performances, preventing falls, risk assessment of falls.

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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] $\leq$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.

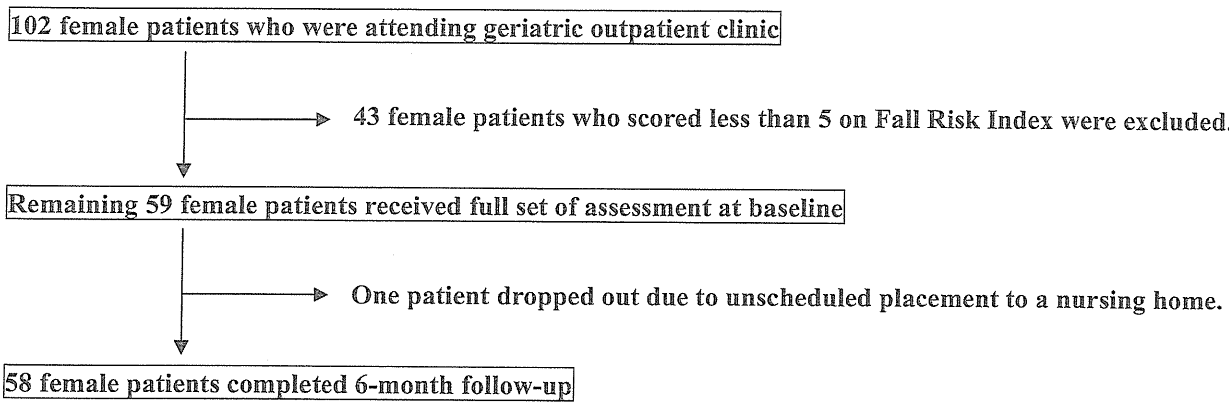

Figure 1 Flowchart showing the selection procedure of participants.

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/m²)	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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Influence of regular exercise on subjective sense of burden and physical symptoms in community-dwelling caregivers of dementia patients: A randomized controlled trial

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ABSTRACT

With an aim to improve quality of life in caregivers of dementia patients, we examined the effect of regular exercise on caregivers' sense of burden and their physical symptoms. Participants were 31 elderly caregivers living with older patients diagnosed with Alzheimer's-type dementia. They were randomly assigned to either the intervention group, who were prescribed regular exercise with moderate-intensity: 3 metabolic equivalents (3METs), 3 times per week for 12 weeks, or the control group, who did not receive any prescription. In the intervention group, significant reductions in the Zarit caregiver burden interview (ZBI) score and in the frequency of feeling fatigued, and an improvement in quality of sleep were observed at follow-up ($p < 0.05$), while no such changes were observed in the control group. These results suggest that obtaining sustainable habit of moderate exercise may improve quality of life in caregivers of demented patients.

1. Introduction

The aging of the population in Japan is occurring at an unprecedented rate, and the ratio of older adults, defined as those aged 65 and above, is estimated to reach 30% by 2023 (Health and Welfare Statistics Association, 2007). Under the urgent pressure of expected increases in the social burden related to the care of the older population, a public long-term care insurance system was launched in 2000 for the purpose of providing sufficient support for disabled older adults and their caregivers. However, it has been suggested that the care burden of caregivers has not necessarily decreased since the introduction of this insurance scheme (Morimoto et al., 2003; Okamoto and Harasawa, 2009).

In particular the psychological burden of care on the caregivers of dementia patients has been suggested to be greater than that on the caregivers of non-dementia patients, presumably due to difficulties in coping with psychological and behavioral symptoms shown by dementia patients (Berger et al., 2005; Onishi et al., 2005). Several reports suggest that the health-related quality of life of dementia caregivers has actually deteriorated (Coen et al., 2002; Takai et al., 2009). Longitudinal burden may be predictive of higher depressive symptoms (Epstein-Lubow et al., 2008). Practitioners estimate that approximately 20% of caregivers are treated for psychiatric disorders such as depression (Riepe and Ibach, 2008). Moreover, possibilities that physical health of those caring for patients with dementia might also be at stake have been strongly suggested by previous studies, which have found a higher prevalence of hypertension (Shaw et al., 1999), reduced lymphocyte sensitivity (Bauer et al., 2000), and a higher mortality rate (Schulz and Beach, 1999) in these individuals.

In Japan, an initiative to promote health called Healthy Japan 21 (Japan Health Promotion and Fitness Foundation, 2000) was initiated by the government. Under this program, regular physical activities requiring moderate strength (such as doing simple gymnastics or walking) are recommended to promote the health of older adults. Despite such encouragement by the government to exercise regularly for physical fitness, it has been shown that elderly caregivers take part in few physical activities (Wilcox et al., 2000). It has been reported that lower levels of physical activity increase the risk of cardiovascular disease (Blair et al., 1989), that the mortality rate of sedentary participants is higher than that of physically active participants (Stessman et al., 2009). On the other hand, increased physical activity levels are also known to contribute to the prevention of cardiovascular disease (Leon et al., 1987; Dubbert, 2002; Salmon, 2003) and to decrease mortality (Davis et al., 2001; Byberg et al., 2009). Hence, the physical health of elderly caregivers of dementia patients might also be at risk due to their reduced opportunities for regular exercise, and beneficial influences on both physical and psychological health by habitual exercise have been

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suggested in previous studies (Courneya et al., 2002; Leppämäki et al., 2002; Bowen et al., 2006).

In general, many intervention studies of dementia caregivers have reported decreased care burden (Rabins, 1998; Gavrilova et al., 2009) through active support and educational programs for their psychological health. The caregivers' burden of depression was found to be decreased (Gaugler et al., 2008) and their quality of life was improved (Belle et al., 2006) by telephone counseling and face-to-face meetings with counselors, including education sessions for disease and recuperation. Another study reported that participants, who were healthy non-caregivers, experienced a positive fitness change and psychological improvement over the initial 12-week program of exercise compared to a control group (DiLorenzo et al., 1999).

Despite a wealth of evidences showing the effect of interventional approaches, there has been little research to date that demonstrated a sole effect of concrete exercise program at home in the caregivers of dementia patients. Adherence to the prescription of exercise in older individuals can often make it difficult to estimate the net effect of exercise, and a previous study, where participants were allowed to choose the intensity of exercise based upon telephone counseling, showed no significant improvement in self-reported physical activity, and three major health promotion barriers heavy caregiving and responsibilities were identified (Farran et al., 2008).

Based upon a recognition of underlying obstacles in implementing regular exercise program for dementia caregivers, we hypothesized that the care burden of dementia caregivers would decrease by providing a sustainable protocol of physical exercise with moderate-intensity. In the present study, we investigated the effectiveness of regular exercise on the subjective sense of burden, the level of physical activity (i.e., daily physical activity), and subjective physical symptoms in elderly caregivers of dementia patients.

2. Subjects and methods

2.1. Participants

Subjects were 50 community-dwelling caregivers aged 65 and older who were living with elderly patients diagnosed with Alzheimer's-type dementia according to the diagnostic criteria set out in the 4th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (APA, 1994). All diagnoses were made by experienced geriatricians. Inclusion criteria included good health, having a good control of chronic medical conditions if any such as hypertension, diabetes or dyslipidemia. Exclusion criteria included those who had a regular exercise (over 30 min a day, more than twice a week) a history of stroke, myocardial infarction, or any serious medical condition that prevented the participant from adhering to the protocols. This study was approved by the ethics committee of the Nagoya University Graduate School of Medicine, and all participants provided their written informed consent.

2.2. Research design

The participants were randomly assigned to an exercise intervention group and a non-exercise control group. In the intervention group, we prescribed regular exercise with moderate-intensity (3METs; metabolic equivalents) (Thompson et al., 2003) 3 times per week for 12 weeks. In the control group, the subjects were not advised to exercise. All participants were asked to carry pedometers that recorded total daily steps and to record their daily progress of exercise amount in a journal.

2.3. Assessment of caregivers and care recipients

Caregivers were evaluated using three assessment tools. First, the Japanese version of the ZBI (Zarit et al., 1980) is a questionnaire that includes 22 items and scores the caregiver's burden on a scale of 0–88 based on physical, psychological and economic factors. Second, physical activity was assessed by the physical activity questionnaire score (QS) for the elderly (Voorrips et al., 1991). The QS comprises three subscales: a household activity score (HS), a sport activity score (SS), and a leisure-time activity score (LS). Items related to the HS were questions with 4–5 possible ratings, ranging from very active to inactive. The SS is an assessment of activity in all types of sports (e.g., walking, golf, gymnastics). The LS assesses leisure activity (e.g., gardening, ceramic art). SS and LS are assessed by the hours per week spent on it, length of time per year during which the activity is normally performed. All activities are graded on their intensity, hours and time of the year. The Visual Analogue Scale (VAS) (Carlsson, 1983) is a simple and commonly used self-rating scale originally developed for the subjective assessment of pain. The subjects express the level of their symptoms on a line from 0 to 100 mm. The VAS was used to assess the mood of caregivers in the present study. Quality of sleep scores were defined, and the subjects were checked for symptoms; points were assigned to each item based on their yes or no answers: light sleep, lying awake in bed, sleeping but still waking several times during the night (0–3). Lower score represents better quality of sleep.

Care recipients were assessed using two assessment tools. First, the Japanese version of the neuropsychiatric inventory (NPI) (Hirono et al., 1997) was used to evaluate the psycho-behavioral symptoms of care recipients. Second, cognitive function and the severity of dementia were assessed using the mini-mental state examination (MMSE; scale of 0–30) (Folstein et al., 1975). All assessments were made both at the initiation and at the completion of the 12-week study period.

2.4. Statistical analysis

Quantitative data analyses were carried out using the SPSS (version 17.0) statistical software. Demographic variables of the two groups were compared using an unpaired *t*-test. Average ZBI score, QS and subscores (HS, SS, LS), quality of sleep score, body mass index (BMI), intensity of physical complaints as assessed by VAS and their frequency (occurrences per month), time spent on caregiving per day, and NPI score, which were all obtained at two points (before and after the observation period), were compared using a paired *t*-test in both groups. Results were considered statistically significant at a level of $p < 0.05$.

3. Results

Of the 50 initial subjects, 11 did not meet the criteria and 3 declined to participate. Thirty-six dementia caregivers were randomly assigned to one of the two groups (exercise, non-exercise) at the entry. During the 12-week study period, five subjects dropped out because they were too busy. The remaining 31 subjects (17 exercise, 14 control) completed the period and were subjected for analyses.

As summarized in Table 1, the mean ± SD age of the study population was 73.7 ± 4.4 years, and ZBI was 35.4 ± 18.8. Of the participants, 67.7% were women and 83.9% (26 of 31 subjects) of them had at least one chronic disease. There was no difference in variables between the intervention and control groups except that subjective complaint of depressive mood measured by VAS was higher in the control group ($p = 0.021$). The average numbers of steps per day recorded by the pedometers for both groups were 9017.0 ± 1927.0 in the exercise group, 5766.3 ± 2602.7 in the control group respectively, and the difference reached a statistical significance ($p < 0.01$).

Table 2 presents the changes of parameters from the baseline values. In the exercise intervention group, the mean ZBI and quality of sleep scores showed significantly reductions at follow-up compared with pre-intervention ($p < 0.05$ for each). Meanwhile

Table 1
Characteristics of the study subjects, *n*, mean ± S.D., *n* (%).

	All	Exercise	Control	*p* =
n	31	17	14	
Caregivers				
Sex, male/female	10/21	6/11	4 /10	0.70
Age	73.7 ± 4.4	72.6 ± 4.0	75.0 ± 4.6	0.13
Caregiving terms (mo)	34.4 ± 23.0	34.3 ± 21.8	34.5 ± 25.2	0.98
Caregiving times (h)	10.1 ± 6.4	8.6 ± 6.2	12.0 ± 6.2	0.14
Hypertension	14(45.2)	9(52.9)	5(35.7)	0.35
Diabetes	8(25.8)	4(23.5)	4(28.6)	0.76
Hypercholesterol	7(22.6)	3(17.6)	4(28.6)	0.49
Other diseases	6(19.4)	3(17.6)	3(21.4)	0.80
ZBI	35.4 ± 18.8	32.9 ± 18.2	38.5 ± 19.7	0.42
QS	2.8 ± 1.5	3.0 ± 1.8	2.5 ± 1.0	0.46
HS	2.1 ± 0.4	2.1 ± 0.3	2.1 ± 0.5	0.62
SS	0.3 ± 0.7	0.5 ± 0.9	0.0 ± 0.1	0.09
LS	0.4 ± 1.3	0.4 ± 1.7	0.4 ± 0.8	0.88
Quality of sleep score	1.5 ± 0.9	1.2 ± 0.9	1.8 ± 0.8	0.06
Pulse rate (beats/min)	75.6 ± 9.9	75.2 ± 9.4	76.0 ± 10.8	0.82
SBP, mmHg	128.0 ± 16.1	132.2 ± 14.4	122.9 ± 17.0	0.11
DBP, mmHg	76.5 ± 9.4	78.0 ± 10.4	74.7 ± 8.1	0.34
BMI	22.1 ± 3.3	22.2 ± 3.3	22.0 ± 3.3	0.86
VAS for symptoms (mm)				
Headache	15.9 ± 25.3	13.1 ± 19.8	19.4 ± 31.2	0.50
Stiff shoulders	27.8 ± 29.1	26.0 ± 30.5	29.9 ± 28.3	0.72
Stethalgia	12.5 ± 25.7	7.4 ± 15.5	18.6 ± 33.9	0.23
Weariness	38.2 ± 29.6	31.8 ± 27.9	46.1 ± 30.6	0.19
Depression*	28.3 ± 25.7	18.8 ± 18.7	39.8 ± 28.8	0.02
Occurrence of symptoms (per month)				
Headache	2.5 ± 6.5	1.2 ± 2.5	4.1 ± 9.2	0.23
Stiff shoulders	9.5 ± 12.6	9.9 ± 13.5	8.9 ± 11.9	0.84
Stethalgia	1.1 ± 2.9	0.8 ± 1.7	1.5 ± 4.0	0.53
Weariness	10.0 ± 11.7	8.2 ± 11.6	12.2 ± 12.0	0.35
Depression	4.9 ± 7.8	3.9 ± 7.7	6.2 ± 8.1	0.42
Patients				
Age	76.9 ± 6.0	75.4 ± 6.4	78.8 ± 5.2	0.12
MMSE	18.3 ± 7.4	19.6 ± 7.9	16.7 ± 6.6	0.28
NPI	15.0 ± 12.0	11.8 ± 7.9	18.9 ± 15.1	0.11

* $p < 0.05$.
** $p < 0.01$.

Table 2
Changes in outcome measures between the baseline and the follow-up, mean ± S.D.

	Exercise	*p* <	Control	*p* <
Caregivers				
ZBI	−5.2 ± −2.1	0.04*	0.7 ± 0.5	0.74
QS	0.9 ± 0.0	0.01**	−0.3 ± −0.0	0.02*
HS	0.1 ± 0.1	0.08	−0.3 ± 0.0	0.02*
SS	0.8 ± 0.1	0.01**	0.0 ± 0.0	0.34
LS	−0.0 ± 0.0	0.41	−0.0 ± −0.1	0.30
Quality of sleep score	−0.5 ± 0.0	0.04*	0.7 ± −0.3	0.01**
Pulse rate	2.4 ± −0.4	0.46	2.0 ± −1.8	0.56
SBP, mmHg	7.8 ± −0.5	0.08	13.1 ± 3.7	0.04*
DBP, mmHg	−0.6 ± −3.3	0.84	3.2 ± 0.8	0.22
BMI	0.0 ± 0.0	0.93	−0.2 ± 0.5	0.59
VAS for symptoms (mm)				
Headache	−2.2 ± −1.8	0.70	4.6 ± 3.1	0.51
Stiff shoulders	2.5 ± −2.5	0.68	6.7 ± 1.8	0.28
Stethalgia	−0.7 ± 3.2	0.87	−4.1 ± −7.6	0.55
Weariness	−6.1 ± 3.5	0.42	1.4 ± 3.7	0.76
Depression	−3.3 ± 0.3	0.39	1.1 ± 4.9	0.85
Occurrence of symptoms (per month)				
Headache	0.6 ± 0.8	0.56	−1.2 ± −1.3	0.42
Stiff shoulders	−4.4 ± −4.6	0.16	3.1 ± 1.2	0.38
Stethalgia	−0.2 ± 0.0	0.63	−1.1 ± −3.1	0.24
Weariness	−5.8 ± −6.4	0.04*	4.1 ± 1.6	0.17
Depression	−0.9 ± −2.0	0.66	−2.1 ± −2.5	0.13
Caregiving time (hours/day)	0.1 ± −0.3	0.89	−0.2 ± −0.6	0.82
Patients				
NPI	4.1 ± 8.0	0.27	−3.6 ± −4.1	0.35

* $p < 0.05$.
** $p < 0.01$.

the ZBI scores showed no significant change, and the quality of sleep scores had increased significantly ($p < 0.01$) in the control group. Overall level of physical activity measured by the QS showed a significant increase in the intervention group, and this increase is mainly explained by the increase of the SS since no other subscales showed significant changes. On the other hand, the QS showed a significant reduction in the control group due to the reduction of HS. Regarding physical symptoms, the number of times per month that subjects reported weariness decreased significantly in the exercise group ($p < 0.05$), while there was a trend of increase in the control group. The intensity and the frequency of other physical complaints assessed by VAS and the number of times per month showed no significant difference from the baseline values in both groups.

4. Discussion

The results of the present study suggests a possibility that the quality of life in caregivers of dementia patients can be improved by appropriate interventions. The effect of regular physical exercise was observed as a significant improvement in the subjective sense of burden assessed by the ZBI, quality of sleep and physical symptoms, while such improvements were not observed in the control group.While home-based intervention studies that combine physical activity with counseling have shown decreased caregiver burden (King and Brassington, 1997; Castro et al., 2002). Another study using a similar strategy of combining physical activity and psychological support revealed negative effect of such program on caregivers sense of burden possibly due to the specific stress associated with their caring role when they returned home remained largely unchanged. Furthermore, it is possible that the stress associated with leaving a care recipient while going to a physical activity program might actually increase caredurden (Hill et al., 2007). In previous studies of physical interventions, the level of intensity and duration of exercise were left at the participants' discretion and it is therefore difficult to estimate their effectiveness or contribution to decreasing caregiver burden. In the present study, on the other hand, a concrete prescription of exercise at home was given to the participants, and thus the magnitude of physical intervention was controlled, and the subjects were able to select convenient time to exercise without the burden of frequent trips to facilities. Adherence to the exercise protocol was confirmed by the fact that the average daily steps of the intervention group were much higher than those of the control group.Hence we believe that the prescription of physical exercise we applied in the present study is sustainable and the favorable effects we confirmed in this short-term observation can be maintained by the continuation of a durable exercise program with moderate-intensity as previously reported. It was also reported that older people who have been exercising moderately for a long time usually have high levels of independence (Spirduso and Cronin, 2001). In the present study, neither counseling nor educational activities were offered as in previous studies. Instead, the sole focus of the present study was home-based physical activity, nothing more. This focus was reinforced by giving concrete prescription of exercise including the intensity, frequency, and the execution of exercise was facilitated by giving pedometers to the participants. Exercise is believed to improve psychological factors such as nervousness (Dracup et al., 1991; Thomas, 1995), satisfaction ratings of work, home life and social life (Hoad and Crawford, 1990), thereby affect quality of life (Yasunaga et al., 2006; Martin et al., 2009). In general, self-efficacy is closely related to the level of physical activity (Allison and Keller, 2004), and the self-efficacy of older people who continue physical activity is reported to be high (McAuley et al., 1993). Moreover, the present study had many caregivers who thought that they were unable to exercise regularly due to a chronic medical condition before they were prescribed regular exercise. Indeed, after the intervention, these subjects were able to continue their habit of regular exercise, which we believe might eventually contribute to the overall improvement of their chronic medical conditions. Moreover, elevating regular physical activity in their daily lives can be expected to have a positive psychological effect. It has been suggested that achievements in setting goals of exercise positively influence caregivers' ability to cope with the harsh situations that arise (Danish et al., 1995). In the present study, caregivers were found to cope better and have more confidence in their abilities as a result of the exercise program.

We also observed changes in the quality of sleep as a result of exercise. Dementia caregivers have been shown to have elevated susceptibility to depression and sleeping problems (Beaudreau et al., 2008). The problems concerning sleep not only relate to the caregivers' psychological health (Creese et al., 2008), but also affect physical outcomes (Von Känel et al., 2006). Likewise, it has been reported that the participants' perception of their quality of sleep was highly associated with their number of medical conditions as approximately 40% of those with major comorbidity perceived their sleep to be of only fair or poor quality. In contrast, among those without medical condition, only 10% reported their sleep quality as fair or poor (Foley et al., 2004).

In the present study, we observed that quality of sleep was improved by exercise. In general, people with high physical activity have better quality of sleep than those with low physical activity (De Castro Toledo Guimaraes et al., 2008), and insomnia among older people without physical or psychological disease is very low (Vitiello et al., 2002). We speculate that the increased physical activity in the present study led to an improvement of quality of sleep, which in turn improved physical and psychological symptoms.

In addition, dementia caregivers often complain of physical pain, and thus, their quality of life is low (Argimon et al., 2004). In keeping with the results of a previous report showing that regular exercise improved not only psychological symptoms but also physical symptoms (Clark et al., 2000), the present study observed not only reduced care burden by exercise but the reduction in the frequency of weariness was also observed. The present results strongly indicate that the quality of life in dementia caregivers can be improved by an appropriate habitual intervention, through the reduction of care burden as a consequence of improvements in both physical and psychological symptoms represented by increased quality of sleep, presumably leading to a reduced sense of weariness after the intervention.

The primary limitation of this intervention study is that the sport score in the intervention group were relatively high at baseline although they did not reach statistical significance. In addition, depressive mood measured by the VAS was more severe in the control group relative to the intervention group even though all the participants were randomly assigned to either one of the two groups. These background factors could have worked as a potential bias in affecting the results obtained. Future studies involving a larger sample size are warranted.

Conflict of interest statement

None.

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