Shimada H	Imaging of glucose uptake during walking in elderly adults	Current Aging Science	5	51-57	2012
原田敦, 秋下雅弘, 江頭正人, 金憲経, 金信敬, 神﨑恒一, 重本和宏, 島田裕之, 下方浩史, 鈴木隆雄, 橋本有弘, 細井孝之	特別報告　サルコペニア：定義と診断に関する欧州関連学会のコンセンサス—高齢者のサルコペニアに関する欧州ワーキンググループの報告—の監訳とQ&A	日老医誌	49(6)	788-805	2012
下方浩史, 安藤富士子	日常生活機能と骨格筋量, 筋力との関連	日老医誌	49	195-198	2012
下方浩史, 安藤富士子	疫学研究からのサルコペニアとそのリスク—特に栄養との関連	日老医誌	49	721-725	2012
金憲経	虚弱・サルコペニアへの介入研究	日老医誌	49	726-730	2012
原田敦	巻頭言 —運動器障害は虚弱における身体的脆弱性にどこまで関与しているのか—	CLINICAL CALCIUM	22(4)	11-12	2012
原田敦	転倒・骨折患者にみられる虚弱(Frailty)	CLINICAL CALCIUM	22(4)	27-33	2012
原田敦	転倒リスクの評価と転倒予防	CLINICAL CALCIUM	22(6)	68-72	2012
原田敦	骨粗鬆症性椎体骨折に対する我が国での医療行為	整形外科最小侵襲手術ジャーナル	64	15-18	2012
原田敦	ロコモティブシンドロームの原因疾患と治療大腿骨近位部骨折	臨床と研究	11	31-34	2012
竹村真里枝, 原田敦	高齢者の骨折	Journal of Clinical Rehabilitation	21(12)	1168-1176	2012

細井孝之, 黒田龍彦, 中村利孝, 白木正孝, 太田博明, 原田敦, 森聖二郎, 大橋靖雄, 折茂肇	全国的データベースを用いた骨粗鬆症性骨折の予防と治療に関する研究	Osteoporosis Japan	20(4)	661-668	2012
安藤富士子, 今井具子, 加藤友紀, 大塚礼, 松井康素, 竹村真里枝, 下方浩史	血清カロテノイドと2年後の骨粗鬆症／骨量減少発症リスクに及ぼす影響	日本未病システム学会雑誌	18	89-92	2012
大矢敏久, 内山靖, 島田裕之, 牧迫飛雄馬, 土井剛彦, 吉田大輔, 上村一貴, 鈴木隆雄	手段的日常生活活動の自立した地域在住高齢者における転倒恐怖感に関連する要因の検討	日老医誌	49(4)	457-462	2012
橋立博幸, 島田裕之, 潮見泰藏, 笹本憲男:	高齢者における筋力増強運動を含む機能的トレーニングが生活機能に及ぼす影響	理学療法学	39(3)	159-166	2012
水本淳, 島田裕之, 井平光, 野村知広, 古名丈人, 鈴川芽久美	ステップエルゴメーターのアイソキネティック運動におけるピークパワーと筋活動特性との関連	理学療法科学	27(4)	411-415	2012
金憲経	地域在住高齢者におけるサルコペニア予防のための包括的介入	日本未病システム学会雑誌	18	66-73	2012
金憲経	地域在住高齢女性におけるサルコペニアとロコモティブシンドローム	Japanese Journal of Rehabilitation Medicine	49(9)	596-599	2012
原田敦	特集　サルコペニア—筋研究の最前線— サルコペニアの定義や診断基準	Bone Joint Nerve	3(1)	9-13	2013
島田裕之, 吉田大輔	サルコペニア診断のための筋量、筋力の評価法	Bone Joint Nerve	3(1)	61-66	2013
金憲経	筋肉への運動や栄養による介入—現状と今後と展望—	Bone Joint Nerve	3(1)	89-95	2013

斎藤充, 原田敦, 村木重之, 重本和宏	特集　サルコペニア―筋研究の最前線―　座談会 サルコペニア―筋研究の最前線―	Bone Joint Nerve	3(1)	139-149	2013
松井康素, 原田敦	特集　老化と生体運動機能　Review　関節の老化	CLINICAL CALCIUM	23(1)	15-22	2013
金憲経	身体活動の指導からみた高齢者支援—老年症候群の早期予防のための支援—	大阪体育学研究	51	41-46	2013
Shimada H, Ishii K, Ishiwata K, Oda K, Suzukawa M, Makizako H, Doi T, Suzuki T	Gait adaptability and brain activity during unaccustomed treadmill walking in healthy elderly females	Gait Posture	38	203-208	2013
Shimada H, Makizako H, Doi T, Yoshida D, Tsutsumimoto K, Anan Y, Uemura K, Ito T, Lee S, Park H, Suzuki T	Combined prevalence of frailty and mild cognitive impairment in a population of elderly Japanese people	JAMDA	14	518-524	2013
Shimada H, Suzuki T, Suzukawa M, Makizako H, Doi T, Yoshida D, Tsutsumimoto T, Anan Y, Uemura K, Ito T, Lee S, Park H	Performance-based assessments and demand for personal care in older Japanese people	BMJ Open	3	e002424	2013
Yoshida D, Suzuki T, Shimada H, Park H, Makizako H, Doi T, Anan Y, Tsutsumimoto K, Uemura K, Ito T, Lee S	Using two different algorithms to determine the prevalence of sarcopenia	Geriatr Gerontol Int	14(Suppl.1)	46–51	2014
Yoshida D, Shimada H, Park H, Anan Y, Ito T, Harada A, Suzuki T	Development of an equation for estimating appendicular skeletal muscle mass in Japanese older adults using bioelectrical impedance analysis	Geriatr Gerontol Int			in press

Kojima N, Kim H, Saito K, Yoshida H, Yoshida Y, Hirano H, Obuchi S, Shimada H, Suzuki T	Association of knee-extension strength with instrumental activities of daily living in community-dwelling older adults	Geriatr Gerontol Int			in press
Yoshimatsu T, Yoshida D, Shimada H, Komatsu T, Harada A, Suzuki T	Relation between near-infrared spectroscopy and subcutaneous fat and muscle thickness measured by ultrasonography in Japanese community-dwelling elderly	Geriatr Gerontol Int	13	351-357	2013
Kim H, Suzuki T, Saito K, Yoshida H, Kojima N, Kim M, Sudo M, Yamashiro Y, Tokimitsu I	Effects of exercise and tea catechins on muscle mass, strength and walking ability in community-dwelling elderly Japanese sarcopenic women: A randomized controlled trial	Geriatr Gerontol Int	13	458-465	2013
Yoshida Y, Iwasa H, Kumagai S, Suzuki T, Yoshida H	Limited Functional health literacy, health information sources, and health behavior among community-dwelling older adults in Japan	ISRN Geriatrics			in press
Yoshimura N, Akune T, Fujiwara S, Shimizu Y, Yoshida H, Omori G, Sudo A, Nishiwaki Y, Yoshida M, Shimokata H, Suzuki T, Muraki S, Oka H, Nakamura K	Prevalence of knee pain, lumbar pain and its coexistence in Japanese men and women: The Longitudinal Cohorts of Motor System Organ (LOCOMO) study	J Bone Miner Metab			in press
曽根稔雅, 中谷直樹, 遠又靖丈, 相田潤, 大久保一郎, 大原里子, 大渕修一, 杉山みち子, 安村誠司, 鈴木隆雄, 辻一郎	介護予防サービス利用者における生活機能の予後予測及び効果的な運動器の機能向上プログラムの実施内容に対する評価	日衛誌	68	11-21	2013

Ito S, Harada A, Kasai T, Sakai Y, Takemura M, Matsui Y, Hida T, Ishiguro N	Use of alfacalcidol in osteoporotic patients with low muscle mass may increase muscle mass: An investigation using a patient database	Geriatr Gerontol Int	14(Suppl.1)	122-128	2014
Nishiyama KK, Ito M, Harada A, Boyd SK	Classification of women with and without hip fracture based on quantitative computed tomography and finite element analysis	Osteoporos Int	25(2)	619-626	2014
Matsui Y, Takemura M, Harada A, Ando F, Shimokata H	Effects of knee extensor muscle strength on the incidence of osteopenia and osteoporosis after six years	J Bone Miner Metab			in press
Matsui Y, Fujita R, Harada A, Sakurai T, Nemoto T, Noda N, Toba K	The association of grip strength and related indices with independence of activities of daily living in the elderly, investigated by a newly-developed grip strength measuring device	Geriatr Gerontol Int	14(Suppl.2)	77-86	2014
Matsui Y, Fujita R, Harada A, Sakurai T, Nemoto T, Noda N, Toba K	A new grip-strength measuring device for detailed evaluation of muscle contraction among the elderly	Journal of Frailty & Aging			in press
Hida T, Harada A, Imagama S, Ishiguro N	Managing sarcopenia and its related-fractures to improve quality of life in geriatric populations	Aging and Disease			in press
Hida T, Ishiguro N, Shimokata H, Sakai Y, Matsui Y, Takemura M, Terabe Y, Harada A	High prevalence of sarcopenia and reduced leg muscle mass in Japanese patients immediately after a hip fracture	Geriatr Gerontol Int	13(2)	413-420	2013

Tauchi R, Imagama S, Inoh H, Yukawa Y, Kanemura T, Sato K, Matsubara Y, Harada A, Hachiya Y, Kamiya M, Yoshihara H, Ito Z, Ando K, Ishiguro N	Risk factors for a poor outcome following surgical treatment of cervical spondylotic amyotrophy: a multicenter study	Eur Spine J	22(1)	156-161	2013
Matsui Y, Takemura M, Harada A, Ando F, Shimokata H	Utility of "loco-check," self-checklist for "Locomotive Syndrome" as a tool for estimating the physical dysfunction of elderly people	Health	5(12A)	97-102	2013
Kimura M, Moriyasu A, Kumagai S, Furuna T, Akita S, Kimura S, Suzuki T	Community-based intervention to improve dietary habits and promote physical activity among older adults: a cluster randomized trial	BMC Geriatr	13	8	2013
原田敦	サルコペニアとロコモティブシンドローム	医学のあゆみ	248(9)	703-709	2014
飛田哲朗, 原田敦	サルコペニアの診断法～高齢者の転倒・骨折予防を目的として～	CLINICAL CALCIUM	23(5)	707-712	2013
原田敦	サルコペニアの診断	腎と骨代謝	26(2)	119-125	2013
原田敦	医療面接・身体診察	日本臨床	71	211-216	2013
原田敦	片足立ち訓練やスクワット訓練による筋力強化が有効　サルコペニアの実態	Medical Tribune	46(23)	24	2013
原田敦, 若尾典充,根本哲也	大腿骨近位部の骨構造と骨強度ー加齢変化と治療による変化ー	CLINICAL CALCIUM	23(7)	943-950	2013
原田敦	サルコペニアの概念と現状ならびに診断について	ANTI-AGING MEDICINE	9(4)	18-21	2013
原田敦	知る、診る、防ぐ！ロコモティブシンドローム虚弱	関節外科	32(10)	1129-1133	2013

Hashidate H, Shimada H, Shiomi T, Shibata M, Sawada K, Sasamoto N	Measuring indoor life-space mobility at home in frail older adults with difficulty to perform outdoor activities	Geriatr Phys Ther	36	109-114	2013
稲葉康子, 大渕修一, 新井 武志, 柴喜崇, 岡浩一朗, 渡辺修一郎, 木村憲, 長澤弘	地域在住高齢者に対する運動介入が1年後の運動行動に与える影響 ランダム化比較試験	日老医誌	50(6)	788-796	2013
金憲経, 鈴木隆雄,吉田英世, 島田裕之, 山城由華吏, 須藤元喜, 仁木佳文	都市部在住高齢女性の膝痛、尿失禁、転倒に関連する歩行要因	日老医誌	50(4)	528-535	2013
Kim M, Kim H	Accuracy of segmental multi-frequency bioelectrical impedance analysis for whole-body and appendicular fat mass and lean soft tissue mass in frail women aged 75 years and older	Eur J Clin Nutr	67	395-400	2013
Sakurai R, Fujiwara Y, Saito K, Fukuya T, Kim MJ, Yasunaga M, Kim H, Ogawa K, Tanaka C, Tsunoda N, Muraki E, Suzuki K, Shinkai S, Watanabe S	Effects of a comprehensive intervention program including hot bathing, on overweight adults: A randomized controlled trial	Geriatr Gerontol Int	13	638-645	2013
Iwasa H, Kai I, Yoshida Y, Suzuki T, Kim H, Yoshida H	Global cognition and 8-year survival among Japanese community-dwelling older adults	Int J Geriatr Psychiatry	28	841-849	2013
須藤元喜, 山城由華吏, 上野加奈子, 金憲経	シート式圧力センサーを用いて計測した歩容左右差による年齢推定	日生理人類会誌	18	125-132	2013
金憲経	サルコペニア予防と健康増進	Geriatr Med	51	937-940	2013

Kim H, Suzuki T, Saito K, Kim M, Kojima N, Ishizaki T, Yamashiro Y, Hosoi E, Yoshida H	Effectiveness of exercise with or without thermal therapy for community-dwelling elderly Japanese women with non-specific knee pain: A randomized controlled trial	Arch Gerontol Geriatr	57	352-359	2013
Sakamoto K, Endo N, Harada A, Sakada T, Tsushita K, Kita K, Hagino H, Sakai A, Yamamoto N, Okamoto T, Liu M, Kokaze A, Suzuki H	Why not use your own body weight to prevent falls? A randomized, controlled trial of balance therapy to prevent falls and fractures for elderly people who can stand on one leg for ≤15 s	J Orthop Sci	18(1)	110-120	2013
金憲経	サルコペニアに対する運動・栄養による介入効果	医学のあゆみ	248	747-752	2013
Kim H, Yoshida H, Suzuki T	Falls and fractures in participants and excluded non-participants of a fall prevention exercise program for elderly women with a history of falls: 1-year follow-up study	Geriatr Gerontol Int			in press
Kim H, Yoshida H, Hu X, Saito K, Yoshida Y, Kim M, Hirano H, Kojima N, Hosoi E, Suzuki T	Association between self-reported urinary incontinence and musculoskeletal conditions in community-dwelling elderly women: A cross-sectional study	Neurourol Urodyn			in press

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The effects of multidimensional exercise on functional decline, urinary incontinence, and fear of falling in community-dwelling elderly women with multiple symptoms of geriatric syndrome: A randomized controlled and 6-month follow-up trial

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ABSTRACT

This study assessed the effects of multidimensional exercises on functional decline, urinary incontinence, and fear of falling in community-dwelling Japanese elderly women with multiple symptoms of geriatric syndrome (MSGS). Sixty-one participants were randomly assigned either to an intervention ($n = 31$) or to a control group ($n = 30$). For 3-month period, the intervention group received multidimensional exercise, twice a week, aiming to increase the muscle strength, walking ability, and pelvic floor muscle (PFM). Outcome variables were measured at baseline, and after intervention and follow-up. The functional decline of the intervention group decreased from 50.0% at baseline to 16.7% after intervention and follow-up ($Q = 16.67$, $p < 0.001$). For urinary incontinence, the intervention group decreased from 66.7% at baseline to 23.3% after intervention and 40.0% at follow-up ($Q = 13.56$, $p = 0.001$), whereas the control group showed no improvement. Intervention group showed greater and significant decrease in the score of MSGS compared to control group ($F = 12.66$, $p = 0.001$). Within the subjects that showed improvement to normal status of MSGS, a significantly higher proportion demonstrated increased maximum walking speed at follow-up ($Q = 6.50$, $p = 0.039$). These results suggest that multidimensional exercise is an effective strategy for reducing geriatric syndromes in elderly population. An increase in walking ability may contribute to the improvement of MSGS.

1. Introduction

The geriatric syndrome such as functional decline, urinary incontinence, and fear of falling are used to capture those clinical conditions that do not fit into discrete disease categories, and are serious problems among the elderly population (Inouye et al., 2007). Many studies have demonstrated that a decline in walking speed, muscle strength and balance ability of the elderly is strongly associated with the development of geriatric syndrome (Vellas et al., 1997; Ishizaki et al., 2000; Maggi et al., 2001).

It is well documented that as age advances, the proportion of people with more than one symptom of geriatric syndrome increases. In addition, people with MSGS have an increased prevalence of functional disability and mortality compared to people with only one or no symptoms present. Several studies have put emphasis on the fact that multidimensional exercises focusing on strength, balance, and mobility improvement, even into advanced age, was helpful in reducing functional decline, urinary incontinence and fear of falling (Nelson et al., 2004; Gitlin et al., 2006; Kim et al., 2007). These previous studies validated the effectiveness of the multidimensional exercises focusing on the improvement of a single geriatric syndrome such as functional decline or urinary incontinence, but did not provide any information on whether the subjects possessed symptoms other than functional decline or urinary incontinence. One study demonstrated (Tinetti et al., 1995) that falls and urinary incontinence were associated with the occurrence of functional decline, and that the identification of shared risk factors associated with falls and urinary incontinence is the key in establishing effective and efficient interventional strategies. However, few multidimensional exercises studies have been performed in community-dwelling elderly persons with MSGS.

In the present study, we hypothesize that deteriorations in muscle strength, walking and balance ability are common risk factors associated with functional decline, urinary incontinence and fear of falling. We conducted a randomized and controlled trial to evaluate the effects of the multidimensional exercises targeted at reducing the symptoms of functional decline, urinary inconti-

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nence, and fear of falling in community-dwelling Japanese elderly women with MSGS.

2. Methods

2.1. Study sample and procedures

Overall health surveys were conducted at the Tokyo Metropolitan Institute of Gerontology (TMIG), aiming at early screening of geriatric syndromes in elderly persons and at developing intervention strategies, which would reduce those geriatric syndromes. As subjects, 1016 women were chosen randomly from the Basic Resident Register as persons aged 70 or older residing in Itabashi ward of Metropolitan Tokyo.

A letter outlining the study and describing its objective, and the way that the personal data would be used was mailed to the elderly women selected, inviting them to participate in the study. The baseline survey was conducted in November 2004, and 669 women aged 70 years and older participated.

The participants were screened based on three geriatric syndromes: functional decline, urinary incontinence, and fear of falling. A person who was reported as having two or more geriatric syndromes present was defined as having MSGS. Out of the 669 women participated, 102 were classified as having MSGS (Fig. 1). A pamphlet containing information on the "Exercise Classes for the Treatment of Geriatric Syndromes" was mailed to the 102 potential participants. A response was obtained from 74 of them, of whom 61 were willing to participate. There were no statistically significant differences in physical fitness, age, and geriatric syndromes between the 61 willing participants and the 41 unwilling ones including those who did not submit any response. The research protocol was approved by the institutional review board, and informed consent was obtained from each participant.

2.2. Randomization

After baseline assessment, subjects were divided into two groups with an allocation ratio of 1:1 according to computer-generated random numbers. There was no attempt to equalize the sizes of the groups based on characteristics or to recruit subjects with specific characteristics. Thereafter, one group was allocated to the intervention ($n = 31$) and the other group to the control ($n = 30$) (Fig. 1).

2.3. Data collection

Data collected by interview and a physical fitness test at baseline, after 3-month exercise, and were reassessed at 6-month follow-up.

2.3.1. Interview survey

A face-to-face interview was conducted to assess the following variables: The functional decline was measured using the TMIG index of competence (Koyano et al., 1991). For each of the 13 items, "yes" was scored as 1 and "no" as 0 (maximum score: 13). A person with a TMIG index score less than 10 was defined as having functional decline. Urinary incontinence was assessed through the question "Have you ever experienced urine leakage during the last 1 year?" If a subject responded with a "yes", we would then ask concerning the frequency of urinary incontinence. The frequency of urinary incontinence was assessed based on a five-point scale through interview (1: several times per year; 2: once or more per month; 3: once or twice per week; 4: once every 2 days; 5: everyday). A person whose response ranged 2–5 was defined as having urinary incontinence (Burgio et al., 1991). The fear of falling was assessed by asking "At this moment, are you afraid of falling?" and classified as "1. not at all", "2. somewhat", "3. very much", and "4. activity restriction due to fear of falling". Subjects who responded within 2 and 4 were assigned to the fear group (Maki et al., 1991).

The effect of the multidimensional exercises on the geriatric syndromes was assessed based on shifts of the responses from the interview, which was conducted at a baseline, completion of the 3-month exercise, and at the 6-month follow-up. The scores of geriatric syndromes were calculated as follows: functional decline, 0 for TMIG index score more than 11, 1 for 10, 2 for 9, and 3 for less than 8; urinary incontinence, 0 for no urine leakage or several times per year, 1 for once or more per month, 2 for once or twice per week, and 3 for once every 2 days or everyday; fear of falling, 0 for not at all, 1 for somewhat, 2 for very much, and 3 for activity restriction due to afraid of falling. The score of MSGS was calculated as add up three geriatric syndrome score (functional decline, urinary incontinence, and fear of falling). And, a participant with a MSGS score less than 1 was defined as improvement of MSGS.

2.3.2. Physical fitness test

Body mass index (BMI) was calculated from body weight (kg) divided by height (m) squared. Physical fitness tests were used for the assessment of muscle strength, walking speed, and balance ability. The following standardized tests were performed: grip strength (Suzuki et al., 2004); adductor muscle strength (Kim et al., 2007); usual and maximum walking speed (Suzuki et al., 2004); one leg standing time with eyes open (Suzuki et al., 2004); tandem walking (Speers et al., 1998); functional reach (Duncan et al., 1990). The staff members who performed the assessments did not know the subjects' group assignments.

2.4. Interventions

2.4.1. Exercise group

The exercise group participated in an intervention comprised of 60-min exercise sessions held at the TMIG Health Promotion Classes, twice per week for 3-month. Weight-bearing exercise: strength training of the thigh, abdominal, and back muscles was performed and included bending the knees, and other similar exercises.

PFM exercise: The exercise regimen was designed to strengthen the fast- and slow-twitch muscle fibers located at the pelvic floor. Participants were initially instructed to perform 10 fast contractions (3-s) with a 5-s relaxation period and 10 sustained contractions (6–8 s) with a 10-s relaxation period in between the contractions. The PFM exercise was performed in sitting, lying, and standing positions with legs apart, emphasizing training of the PFM and relaxation of the other muscles.

Chair exercises: Used in the early stage of the program. The exercises included seated toe and heel raises, seated lift foot and point/flex toes, and others.

Resistance band exercise: Focused on increasing the strength of the muscles of the upper extremities, abdomen, and lower extremities in frail elderly people (arm pull back, leg extension, and others).

Ball exercise: Exercises with a training ball were conducted using a small (diameter: 21 cm) and a large ball (diameter: 45–55 cm), aiming to increment the muscle strength and balance (sitting on the ball and extending legs, and others).

Walking ability training: Focused on maintenance of stability during walking and on the improvement of responses to postural changes during walking (walking with directional changes, gait pattern variations and enhancement, and others).

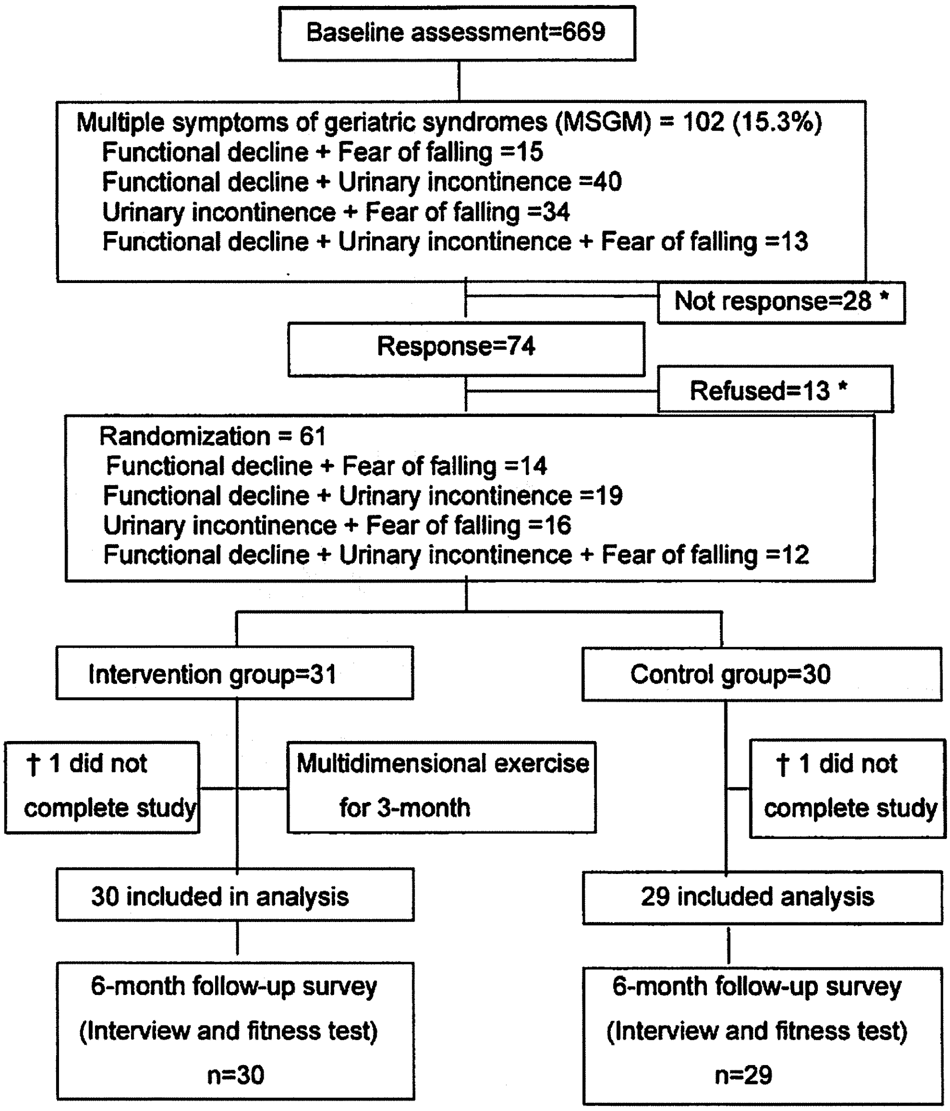

Fig. 1. Flow chart of participants through the randomized controlled trial of the exercise program and analysis. (*) Forty-one of MSGM ($n = 102$) were excluded due to the not response ($n = 28$) and refusal ($n = 13$). (†) Two subjects could not complete the study because of hospitalization ($n = 1$), and fracture ($n = 1$).

Balance training: Focused on the improvement of the static, dynamic, and lateral balancing ability (multidirectional weight shifts, tandem walking, and others).

2.4.2. Control group

The control group attended a general health education class (albumin, osteoporosis, and prevention of malnutrition) held at the TMIG once a month for a 3-month period.

2.5. Follow-up and compliance

During the 6-month follow-up period, subjects of the intervention group attended group exercise classes (60 min) once per month in addition to receiving a home-based exercise program. The home-based exercise program consisted of two to three sets of the 15 exercises and PFM exercise that they had learned during the group exercise session. They were also advised to do the home-based exercises at least three times or more per week for about 30-min per day. In order to accurately monitor the exercise times and the number of sets performed at home during the follow-up period, a pamphlet illustrating the PFM and strengthening exercises and a recording sheet were distributed to the participants, who were instructed to record the time and sets of exercises performed at home everyday. The record sheets were collected once a month at the group exercise class and analyzed in order to calculate the mean exercise frequency per week, and the mean exercise time per day.

2.6. Statistical analysis

Both the mean and standard deviation were calculated for each variable. The differences in the baseline data between the

Table 1
Selected variable characteristics of participants at baseline by study group, mean ± S.D.

Variables	Intervention group	Control group	$p^{\dagger}$
Number	31	30	
Age (year)	79.0 ± 3.9	78.1 ± 4.4	0.424
Height (cm)	146.9 ± 5.4	147.0 ± 5.8	0.940
Body weight (kg)	47.4 ± 6.4	50.7 ± 9.1	0.108
BMI (kg/m^2)	22.0 ± 2.6	23.4 ± 3.6	0.084
One leg standing time (s)	29.2 ± 23.5	34.6 ± 22.8	0.367
Tandem walking (step)	7.2 ± 4.7	7.8 ± 4.7	0.631
Functional reach (cm)	31.0 ± 7.1	33.2 ± 4.9	0.167
Grip strength (kg)	16.5 ± 4.3	17.9 ± 4.7	0.239
Adductor muscle strength (kg)	17.3 ± 4.0	18.0 ± 5.1	0.740
Usual walking speed (m/s)	1.1 ± 0.3	1.2 ± 0.2	0.685
Maximal walking speed (m/s)	1.7 ± 0.4	1.7 ± 0.4	0.979
TMIG index score (point)	10.6 ± 1.6	10.4 ± 1.5	0.654
Urinary incontinence, yes (%)	64.5	50.0	0.252
Functional decline, yes (%)	51.6	43.3	0.517
Fear of falling, yes (%)	67.7	76.7	0.390
Chronic medical conditions, yes (%)			
Hypertension	58.1	60.0	0.902
Stroke	13.2	13.3	0.988
Diabetes	19.4	20.0	0.948

† Two group t-test for continuous variables and the χ^2-test for categorical variables.

exercise and control group were analyzed using t-test for the continuous variables and Chi-square test for the categorical variables. The changes in dependent variables pre-intervention, post-intervention and follow-up in the exercise and control group were analyzed using an analysis of variance (ANOVA) with repeated measures. Significant interactions were analyzed to determine whether or not the effects were greater in the intervention than the control group. Cochran's Q-test was used to evaluate within-group differences of the effect of the exercise on the categorical variables for pre-intervention, post-intervention, and follow-up data. In the case of items which were showing significant differences, a post hoc analysis was performed using McNumar's test. One-way ANOVA was performed to evaluate the within-subgroup effect of the intervention on multiple geriatric syndrome scores at baseline, after the 3-month exercise, and at 6-month follow-up. For the subgroup showing significant differences, a post hoc analysis was performed using Scheffe's method. The percentage improvement in physical fitness was calculated using the following formula: % improvement = {(after 3-month exercise or at 6-month follow-up values − baseline value)/baseline value × 100). The percentage improvement was divided into tertiles. The power of the current study was calculated at 80% to demonstrate a difference in the outcome variable of at least 20% at a significance level of alpha = 0.05. All the analyses were performed using the SPSS software package for Windows version 15.0 (SPSS, Inc., Tokyo, Japan).

3. Results

There were no significant differences between the groups in any of the baseline characteristics such as age, BMI, walking speed, adductor muscle strength, functional decline, urinary incontinence, fear of falling, and chronic medical conditions (Table 1).

Attendance 15 (62.5%) or more than of the exercise sessions (24) was defined as trial completion. Two participants (3.3%) could not complete the trial after the randomization because of hospitalization ($n = 1$) and fracture ($n = 1$) (Fig. 1). The mean attendance rate was 77.4% (61.3–90.3%) during the intervention period and 74.2% during the follow-up. In the exercise group, 32.3% of the subjects attended the exercise sessions 24 times, 22.6% attended 20–23 times, 35.5% attended 16–19 times, 6.5% attended 15 times, and 3.3% attended 14 or less of the exercise sessions. During the follow-up, the mean frequency of performing the

Table 2
Comparison of physical fitness and geriatric syndrome variables between intervention = I ($n = 30$) and control = C ($n = 29$) groups after 3-month exercise and at 6-month follow-up, mean ± S.D.

Variables	Gr	Baseline	3-Month exercise	6-Month follow-up	ANOVA F=	p=
Body weight (kg)	I	46.6 ± 5.4	47.4 ± 5.4	47.1 ± 5.4	(1,57) = 2.74	0.105
	C	51.0 ± 9.5	51.0 ± 9.4	50.6 ± 9.1		
BMI (kg/m^2)	I	21.5 ± 2.2	21.9 ± 2.2	21.8 ± 2.2	(1,57) = 2.82	0.100
	C	23.4 ± 3.9	23.4 ± 3.8	23.3 ± 3.6		
One leg standing time (s)	I	34.0 ± 24.2	28.2 ± 20.4	32.4 ± 22.6	(1,57) = 0.01	0.920
	C	33.4 ± 23.4	28.8 ± 23.5	32.4 ± 24.6		
Tandem walking (step)	I	7.2 ± 4.7	6.1 ± 4.5	5.9 ± 3.3	(1,57) = 4.70	0.036
	C	7.8 ± 4.7	5.2 ± 3.8	3.5 ± 2.0		
Functional reach (cm)	I	31.7 ± 6.8	33.5 ± 5.13	3.5 ± 4.4	(1,56) = 4.18	0.046
	C	33.7 ± 4.7	32.7 ± 5.3	31.6 ± 8.8		
Grip strength (kg)	I	17.2 ± 4.0	20.9 ± 5.2	17.9 ± 4.7	(1,57) = 0.02	0.874
	C	18.0 ± 4.6	21.5 ± 5.1	18.6 ± 4.8		
Adductor muscle strength (kg)	I	17.2 ± 4.0	18.9 ± 5.1	19.3 ± 4.7	(1,57) = 4.18	0.045
	C	17.9 ± 5.0	18.2 ± 4.01	17.8 ± 3.7		
Usual walking speed (m/s)	I	1.1 ± 0.3	1.1 ± 0.2	1.2 ± 0.2	(1,57) = 13.03	0.001
	C	1.2 ± 0.2	1.1 ± 0.3	1.1 ± 0.3		
Maximal walking speed (m/s)	I	1.7 ± 0.4	1.8 ± 0.5	1.8 ± 0.4	(1,56) = 4.24	0.044
	C	1.7 ± 0.4	1.6 ± 0.4	1.6 ± 0.4		
Functional decline, yes (%)	I	50.0	16.7	16.7	16.67^a	<0.001
	C	41.4	31.0	27.6	4.10^a	0.109
Urinary incontinence, yes (%)	I	66.7	23.3	40.0	13.56^a	0.001
	C	51.7	44.8	44.8	4.00^a	0.135
Fear of falling, yes (%)	I	66.7	70.0	70.0	0.17^a	0.920
	C	75.9	62.1	75.9	2.91^a	0.234

^{a} Cochran's Q-value.

Table 3
Improvement of MSGS according to maximum walking speed and adductor muscle strength tertiles in intervention group.

Survey variable	Changes compared to baseline[a]	Improvement of MSGS[†] n (%)	Cochran's Q-value	p	Post hoc[‡]
3-Month exercise ($n=8$)					
Maximum walking speed	Increased	3 (37.5)	2.80	0.247	
	No change	4 (50.0)			
	Decreased	1 (12.5)			
Adductor muscle strength	Increased	3 (37.5)	0.50	0.779	
	No change	3 (37.5)			
	Decreased	2 (25.0)			
6-Month follow-up ($n=7$)					
Maximum walking speed	Increased	5 (71.4)	6.50	0.039	In > De
	No change	1 (14.3)			
	Decreased	1 (14.3)			
Adductor muscle strength	Increased	3 (42.8)	0.57	0.713	
	No change	2 (28.6)			
	Decreased	2 (28.6)			

[a] Decreased (De) means lower range (0.0–33.3%), no change (no) means medium range (33.4–66.6%), and increased (In) means upper range (66.7–100%) of tertile.

exercise series at home was 3.8 times per week (23.3% performed everyday, 50.0% 2-3 times per week, 26.7% once or less per week), while the mean exercise time was 29.0 min.

The exercise group showed significant improvement compared with the control group in muscle strength, walking speed and balance. There was a significant group by time interaction for tandem walking ($F=4.70$, $p=0.036$), functional reach ($F=4.18$, $p=0.046$), adductor muscle strength ($F=4.18$, $p=0.045$), usual walking speed ($F=13.03$, $p=0.001$), and maximum walking speed ($F=4.24$, $p=0.044$) with significantly greater increases in the exercise group. The functional decline decreased significantly from 50.0% at baseline to 16.7% after the intervention and follow-up in the exercise group ($Q=16.67$, $p<0.001$), whereas the changes were not significant in the control group. Urinary incontinence was decreased significantly from 66.7% at baseline to 23.3% after the intervention and to 40.0% at the follow-up ($Q=13.56$, $p=0.001$) in the exercise group. However, no significant changes observed in the control group. There were no significant changes concerning fear of falling in either group (Table 2).

Fig. 2 shows the changes in the scores of multiple geriatric syndromes. As shown in Fig. 2, the intervention group showed greater and significant decrease compared with the control group ($F=12.66$, $p=0.001$). Within-group scores were compared, and significant changes were observed in intervention group, with the score of multiple geriatric syndromes decreasing significantly after 3-month exercise and at 6-month follow-up ($F=16.89$, $p<0.001$).

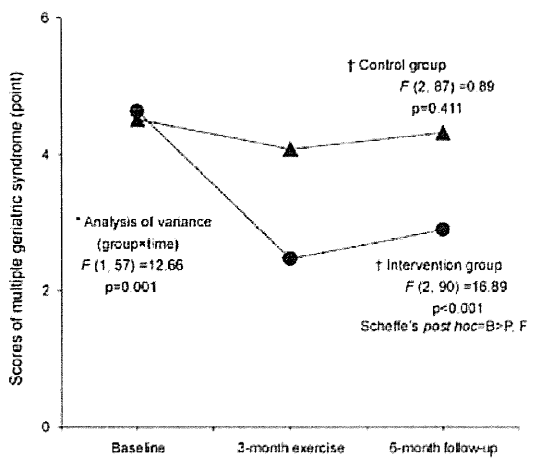

Fig. 2. Change in mean scores of MSGS at baseline, after 3-month exercise, and at 6-month follow-up in intervention (●) and control (▲) group. (*) Comparison of multiple geriatric syndrome scores between intervention and control group. (†) Comparison of within-group multiple geriatric syndrome scores at baseline (B), after the 3-month exercise (P), and at 6-month follow-up (F).

Eight subjects after 3-month intervention and seven subjects after 6-month follow-up were improved to normal status of multiple symptoms in the intervention group. Table 3 shows the distribution of the subjects who showed improvement to normal status of multiple symptoms according to the tertiles of maximum walking speed and adductor muscle strength. Within the subjects that showed improvement to normal status of multiple symptoms, a significantly higher proportion had an improved maximum walking speed at the 6-month follow-up ($Q=6.50$, $p=0.039$) compared with those having maintained or decreased walking speed. There was no difference at either time point in the proportion of the improved subjects with increased adductor muscle strength.

4. Discussion

This study demonstrates that the 3-month, multidimensional exercises, consisting of progressive strength training, balance and walking ability exercises along with PFM exercises, improved the usual walking speed, maximum walking speed, abductor muscle strength, tandem walking and functional reach in community-dwelling elderly women with MSGS. Furthermore, the increment of the physical fitness components appeared to contribute greatly to the improvement of the functional decline, urinary incontinence, and multiple symptoms. Therefore, the results of this study suggest that the improvements of the muscle strength, walking speed, and balance, which have been reported as risk factors for geriatric syndromes, may be effective in the improvement of geriatric syndrome.

Several studies of multidimensional intervention trials have reported beneficial effects (Tinetti et al., 1994; Shumway-Cook et al., 1997; Nelson et al., 2004; Gitlin et al., 2006; Kim et al., 2007). In a recent study, Gitlin et al. (2006) conducted a multidimensional home-based intervention in elder adults with functional difficulties, and confirmed that activity of daily living (ADL), instrumental ADL, self-efficacy, fear of falling, and home hazards were all improved and that the effects were sustained even after 6-month. Kim et al. (2007) assessed the effect of PFM and fitness exercises in improving urinary incontinence in elderly community-dwelling Japanese with stress urinary incontinence, and confirmed that decrease in BMI and increase in walking speed may contribute to the treatment of urinary incontinence.

In this study, the prevalence of the functional decline decreased significantly from 50.0% before the intervention to 16.7% after intervention and follow-up. The cure rate of urinary incontinence was 43.3% after the 3-month exercise and 26.7% at 6-month follow-up for the intervention group. On the other hand, no significant improvement was observed in the control group. The effects of this multidimensional exercise affecting only a single symptom of urinary incontinence or functional decline were consistent with previously reported studies. Although the previous studies using multidimensional intervention were targeted to treat only a single geriatric syndrome, the current study was aiming to treat MSGS. Our findings suggest that the multidimensional intervention was significantly effective in the improvement of geriatric syndrome.

We analyzed the relationship between the increment of the physical fitness components and the improvement of the multiple symptoms, despite the small sample size. We found an increment rate of 9.6% in adductor muscle strength after the 3-month exercise and a rate of 12.3% after the follow-up in the intervention group, whereas the changes were not significant for the control group. This difference in the increment rate of muscle strength is not considered to account for the difference in geriatric syndrome improvement rate. However, the proportion of the subjects with improved to normal status of multiple symptoms was significantly higher among those who demonstrated an increase in maximum walking speed at 6-month follow-up ($Q = 6.50$, $p = 0.039$). These results suggest that the increment of walking speed is a major factor for the improvement of the multiple symptoms present in this population. The increased walking ability probably allowed the subjects to increase their physical activity and consequently contributed to the improvement of their functional capacity. But, the current study's results were obtained based on a small sample size. The above relationships need to be further researched in a population study which would contain a larger number of subjects and for a longer follow-up period.

Despite the fact that many studies have reported that exercise is effective in reducing the fear of falling in the elderly (Tennstedt et al., 1998), our intervention had no effect on the fear of falling in both groups. This may be explained by the characteristics of the intervention provided in the present study. Our multidimensional exercises focused on increasing the physical function and did not provide measures such as psychological care. These findings indicate that the comprehensive strategy designed to reduce MSGS in community-dwelling elderly women should include not only exercises addressing to the improvement of the physical functions, but should also incorporate psychological care focusing on reducing the fear of falling.

This study has several limitations. Firstly, the functional decline, urinary incontinence, and fear of falling were assessed using self-reported data obtained through a face-to-face interview, and they were not confirmed by objective and clinical methods. However, several previous studies have indicated that self-reported data have high validity, reliability and objectivity in the analyses of the functional decline, urinary incontinence, and fear of falling (Smith et al., 1990; Howland et al., 1993; Resnick et al., 1994). Therefore, the use of data collected from interviews or self-recording in analyses has minor influence on the interpretation of the results of this study. Secondly, although this study indicates that improvement of physical fitness components such as muscle strength and walking ability contributes to the treatment of geriatric syndrome, it provides no explanation of the mechanism of how increasing functional fitness component improves multiple geriatric symptoms.

5. Conclusions

This study assessed the effects of multidimensional exercises on functional decline, urinary incontinence, and fear of falling in community-dwelling Japanese elderly women with MSGS. The intervention program targeted modification of physical fitness may contribute to a reduction of the functional decline and urinary incontinence, but was not a diminishing symptom over time concerning the fear of falling. Therefore, the intervention strategies designed to reduce MSGS in elderly persons should include not only exercises aiming to the improvement of the physical functions, but should also incorporate psychological care focusing on the reduction of the fear of falling.

Conflict of interest statement

The authors have no conflict of interest to disclose.

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References

Burgio, K.L., Matthews, K.A., Engel, B.T., 1991. Prevalence, incidence and correlates of urinary incontinence in healthy, middle-aged women. J. Urol. 146, 1255–1259.
Duncan, P.W., Weiner, D.K., Chandler, J., Studenski, S., 1990. Functional reach: a new clinical measure of balance. J. Gerontol. Med. Sci. 45, M192–M197.
Gitlin, L.N., Winter, L., Dennis, M.P., Corcoran, M., Schinfeld, S., Hauck, W.W., 2006. A randomized trial of a multicomponent home intervention to reduce functional difficulties in older adults. J. Am. Geriatr. Soc. 54, 809–816.
Howland, J., Peterson, E.W., Levin, W.C., Fried, L., Bak, S., 1993. Fear of falling among the community-dwelling elderly. J. Aging Health 5, 229–243.
Inouye, S.K., Studenski, S., Tinetti, M.E., Kuchel, G.A., 2007. Geriatric syndromes: clinical, research, and policy implications of a core geriatric concept. J. Am. Geriatr. Soc. 55, 780–791.
Ishizaki, T., Watanabe, S., Suzuki, T., Shibata, H., Haga, H., 2000. Predictors for functional decline among nondisabled older Japanese living in a community during a 3-year follow-up. J. Am. Geriatr. Soc. 48, 1424–1429.
Kim, H., Suzuki, T., Yoshida, Y., Yoshida, H., 2007. Effectiveness of multidimensional exercises for the treatment of stress urinary incontinence in elderly community-dwelling Japanese women: a randomized, controlled, crossover trial. J. Am. Geriatr. Soc. 55, 1932–1939.
Koyano, W., Shibata, H., Nakazato, K., Haga, H., Suyama, Y., 1991. Measurement of competence: reliability and validity of the TMIG index of competence. Arch. Gerontol. Geriatr. 13, 103–116.
Maggi, S., Minicuci, N., Langlois, J., Pavan, M., Enzi, G., Crepaldi, G., 2001. Prevalence rate of urinary incontinence in community-dwelling elderly individuals: the Veneto study. J. Gerontol. Med. Sci. 56A, M14–M18.
Maki, B.E., Holliday, P.J., Topper, A.K., 1991. Fear of falling and postural performance in the elderly. J. Gerontol. Med. Sci. 46, M123–M131.
Nelson, M.E., Layne, J.E., Bernstein, M.J., Nuernberger, A., Castaneda, C., Kaliton, D., Hausdorff, J., Judge, J.O., Buchner, D.M., Roubenoff, R., Singh, M.A.F., 2004. The effects of multidimensional home-based exercise on functional performance in elderly people. J. Gerontol. Med. Sci. 59A, 154–160.
Resnick, N.M., Beckett, L.A., Branch, L.G., Scherr, P.A., Wetle, T., 1994. Short-term variability of self report of incontinence in older persons. J. Am. Geriatr. Soc. 42, 202–207.
Shumway-Cook, A., Gruber, W., Baldwin, M., Liao, S., 1997. The effect of multidimensional exercise on balance, mobility, and fall risk in community-dwelling older adults. Phys. Ther. 77, 46–57.
Smith, L.A., Branch, L.G., Scherr, P.A., Wetle, T., Evans, D.A., Hebert, L., Taylor, J.O., 1990. Short-term variability of measures of physical function in older people. J. Am. Geriatr. Soc. 38, 993–998.
Speers, R.A., Ashton-Miller, J.A., Schultz, A.B., Alexander, N.B., 1998. Age differences in abilities to perform tandem stand and walk tasks of graded difficulty. Gait Posture 7, 207–213.
Suzuki, T., Kim, H., Yoshida, H., Ishizaki, T., 2004. Randomized controlled trial of exercise intervention for the prevention of falls in community-dwelling elderly Japanese women. J. Bone Miner. Metab. 22, 602–611.
Tennstedt, S., Howland, J., Lachman, M., Peterson, E., Kasten, L., Jette, A., 1998. A randomized, controlled trial of a group intervention to reduce fear of falling and

associated activity restriction in older adults. J. Gerontol. Psychol. Sci. 53B, P384–P392.
Tinetti, M.E., Baker, D.L., McAvay, G., Claus, E.B., Garrett, P., Gottschalk, M., Koch, M.L., Trainor, K., Horwitz, R.I., 1994. A multifactorial intervention to reduce the risk of falling among elderly people living in the community. N. Engl. J. Med. 331, 821–827.
Tinetti, M.E., Inouye, S.K., Gill, T.M., Doucette, J.T., 1995. Shared risk factors for falls, incontinence, and functional dependence: unifying the approach to geriatric syndromes. J. Am. Med. Assoc. 273, 1348–1353.
Vellas, B.J., Wayne, S.J., Romero, L.J., Baumgartner, R.N., Garry, P.J., 1997. Fear of falling and restriction of mobility in elderly fallers. Age Ageing 26, 189–193.

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RESEARCH ARTICLE | Open Access

Relationship between subjective fall risk assessment and falls and fall-related fractures in frail elderly people

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Abstract

Background: Objective measurements can be used to identify people with risks of falls, but many frail elderly adults cannot complete physical performance tests. The study examined the relationship between a subjective risk rating of specific tasks (SRRST) to screen for fall risks and falls and fall-related fractures in frail elderly people.

Methods: The SRRST was investigated in 5,062 individuals aged 65 years or older who were utilized day-care services. The SRRST comprised 7 dichotomous questions to screen for fall risks during movements and behaviours such as walking, transferring, and wandering. The history of falls and fall-related fractures during the previous year was reported by participants or determined from an interview with the participant's family and care staff.

Results: All SRRST items showed significant differences between the participants with and without falls and fall-related fractures. In multiple logistic regression analysis adjusted for age, sex, diseases, and behavioural variables, the SRRST score was independently associated with history of falls and fractures. Odds ratios for those in the high-risk SRRST group (≥ 5 points) compared with the no risk SRRST group (0 point) were 6.15 ($p < 0.01$) for a single fall, 15.04 ($p < 0.01$) for recurrent falls, and 5.05 ($p < 0.01$) for fall-related fractures. The results remained essentially unchanged in subgroup analysis accounting for locomotion status.

Conclusion: These results suggest that subjective ratings by care staff can be utilized to determine the risks of falls and fall-related fractures in the frail elderly, however, these preliminary results require confirmation in further prospective research.

Background

Falls and fall-related fractures are a common cause of disability in elderly people [1], and preventing falls is an urgent medical and social issue. Numerous studies have identified factors that predict an increased risk of falls, and many validated assessment tools have been developed to determine fall risks for elderly people [2,3]. Although falls can be caused by multiple factors, mobility impairments such as gait and balance disorders are among the most common predisposing conditions [4,5].

Our previous studies have identified the best mobility tests [6] and a physical performance test [7] for predicting falls in the elderly. These objective measurements can be used to identify people who are appropriate for and who will gain benefit from targeted falls prevention interventions. However, we found that about half of the frail elderly subjects could not complete physical performance tests such as the functional reach test and tandem walk test [7]. In addition, cognitive impairment, particularly confusion, impaired orientation, and misperception of functional ability, is one of the most important risk factors for falls in elderly people [8,9] and is likely to be an important inclusion in a screening tool. Successful strategies for preventing falls in frail elderly people with cognitive impairments are yet to be identified conclusively [10] and appropriate screening tools for these individuals are needed.

Some subjective assessments by care staff have been developed for identifying fall risks in frail elderly adults [11-13]. In a residential facility, staff members possess knowledge of their residents' potential fall risk over a

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24-hour period, and this encompasses both predisposing and precipitating factors. Therefore, their global assessment of fall risk could have the highest predictive validity in relation to falls [13]. These global assessment scales are composed of one item, e.g. 'how do you judge the risk that Mr or Mrs × will fall within 6 months–high or low?' [11,13], which can be used easily in clinical settings, but a global assessment cannot identify specific fall risks and appropriate interventions in frail elderly persons who have multifactorial risks for falls. We determined seven specific tasks with high risks of falls based on a nationwide survey of falls in the frail elderly [7,14], and identified the relationship between these tasks and falls in our preliminary study [15]. However, it was not clear that these tasks were related independently with falls and fall-related fractures in a large population study.

The purpose of this study was to develop the subjective risk rating of specific tasks (SRRST) for screening for the risk of falls and fall-related fractures. Subjects were frail elderly people enrolled in the Tsukui Ordered Useful Care for Health (TOUCH) program which provides day-care services.

Methods

Participants

This study recruited 5,062 elderly participants (mean age, 82.6 ± 7.4 years) enrolled in the TOUCH program. To enrol in TOUCH, an individual must be aged 65 or older and have been certified as needing long-term care by the Japanese public long-term care insurance system [16]. The TOUCH sites are located throughout Japan and provide comprehensive, facility-based day-care services. TOUCH clients have some physical disability and frailty, as defined by the presence of weakness, reduced physical activity or slow gait, which is in accordance with the widely accepted definition of frailty [17]. We limited the participants of this study to those who were aged less than 65 years and who had missing value in measurements. Informed consent was obtained from all participants or a family member prior to their inclusion in the study and the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology approved the study protocol.

Study procedures

This study was performed by cross-sectional design and falls and fall-related fractures were investigated retrospectively for a one-year period. Prior to the commencement of the study, all staff received a measurement manual which mentioned the correct protocols for administering all of the assessment measures included in the study.

Falls and fall-related fractures during the previous year

A fall was defined as "an event that resulted in a person coming to rest unintentionally on the ground or another lower level that did not result from a major intrinsic event or an overwhelming hazard" [18,19]. Falls and fall-related fractures were measured retrospectively for a one-year period via a self-report questionnaire and care records. A caregiver or family member provided information on the participant's annual incidence of falls and fall-related fractures when the trained nurses or care workers recognized that a participant had problems recalling such events.

Subjective risk rating of specific tasks (SRRST)

The SRRST was conducted by day-centre staff who had nursing, allied health or similar qualifications, and they were familiar with their clients. The staff answered the questions of the SRRST based on the present status of the participants. The SRRST consisted of the following items: 1) "Do you feel there is a risk of falls when the client (Mr or Mrs X) is walking?"; 2) "Do you feel there is a risk of falls when the client is transferring in bed room, toilet, or bath room?"; 3) "Do you feel there is a risk of falls when the client is toileting?"; 4) "Do you feel there is a risk of falls when the client is ascending or descending stairs?"; 5) "Do you feel there is a risk of falls when the client is wandering?"; 6) "Do you feel there is risk of falls because the client exhibits risky behavior?"; 7) "Do you feel there is a risk of falls because the client is agitated?". The response to each item in the SRRST was designated as "yes" (1 point) or "no or not applicable" (0 points) [15]. The information of the SRRST and history of falls was obtained at the same time. Prior to the commencement of the study, three raters completed the SRRST twice at weekly intervals (n = 4 × 2 × 30), and test-retest and inter-rater (one physical therapist, one nurse, and two caregivers) reliability comparisons of total scores revealed intraclass correlation coefficients (ICCs) of 0.84 to 0.96 and 0.81, respectively [20].

Potential confounding factors of falls

With reference to previous studies [2,21-24], we selected two demographic variables, eight primary diseases or general health statuses, and two behavioural variables as possible confounding factors of falls (Table 1). The demographic variables were sex and age. Primary diseases or general health status were recorded by the care staff, who identified the chronic condition from care records or symptoms. The following diseases and general health status were included in the analysis: history of stroke with symptoms of hemiparesis, knee osteoarthritis with pain, Parkinson disease, dementia, poor vision, urinary incontinence or frequency, psychotropic use, and walking aid use. Absence of habitual exercise and daily use of slippers or sandals were investigated as behavioural variables.

Table 1 Number of participants with falls and fall-related fractures and odds ratios of potential risk factors

	Single fall		Recurrent falls		Fractures	
	Number (%)	Odds ratio (95% CI)	Number (%)	Odds ratio (95% CI)	Number (%)	Odds ratio (95% CI)
Subjective risk rating of specific tasks						
Risk of falls during walking, yes	1068 (41.5)†	2.21 (2.01-2.43)	633 (24.6)†	3.15 (2.71-3.66)	123 (4.8)†	1.83 (1.36-2.46)
Risk of falls during transferring, yes	823 (41.7)†	1.80 (1.66-1.96)	504 (25.5)†	2.43 (2.14-2.76)	103 (5.2)†	1.89 (1.43-2.51)
Risk of falls during toileting, yes	568 (42.9)†	1.66 (1.53-1.80)	361 (27.3)†	2.18 (1.93-2.47)	65 (4.9)†	1.49 (1.11-2.00)
Risk of falls during stair ascending/ descending, yes	1140 (39.2)†	2.13 (1.93-2.36)	685 (23.6)†	3.55 (2.99-4.22)	139 (4.8)†	2.10 (1.53-2.90)
Risk of falls during wandering, yes	453 (44.9)†	1.68 (1.55-1.83)	289 (28.7)†	2.16 (1.90-2.44)	66 (6.5)†	2.18 (1.63-2.91)
Risk of falls because of risky behaviors, yes	672 (41.6)†	1.66 (1.53-1.80)	424 (26.3)†	2.24 (1.98-2.54)	79 (4.9)†	1.55 (1.17-2.06)
Risk of falls because of agitation, yes	479 (45.0)†	1.70 (1.57-1.85)	316 (29.7)†	2.32 (2.05-2.62)	55 (5.2)†	1.55 (1.14-2.11)
Potential confounding factors						
Age, years‡ Falls or fractures	82.9 ± 7.5		83.0 ± 7.5		84.3 ± 6.9†	
No falls or fractures	82.5 ± 7.4		82.6 ± 7.4		82.6 ± 7.4	
Sex, female	1062 (30.1)	0.97 (0.89-1.06)	560 (15.8)	0.90 (0.79-1.03)	151 (4.3)†	1.77 (1.24-2.52)
Stroke, yes	345 (32.0)	1.07 (0.97-1.18)	175 (16.2)	0.99 (0.85-1.16)	41 (3.8)	1.03 (0.74-1.45)
Knee osteoarthritis and pain, yes	659 (36.7)†	1.36 (1.26-1.48)	362 (20.1)†	1.41 (1.25-1.60)	77 (4.3)	1.26 (0.95-1.67)
Dementia, yes	670 (34.3)†	1.23 (1.13-1.34)	387 (19.8)†	1.40 (1.23-1.58)	80 (4.1)	1.18 (0.89-1.57)
Poor vision, yes	239 (37.9)†	1.30 (1.16-1.45)	131 (20.8)*	1.32 (1.12-1.56)	26 (4.1)	1.13 (0.74-1.73)
Parkinson disease, yes	163 (44.7)†	1.53 (1.35-1.73)	104 (28.5)†	1.85 (1.55-2.20)	16 (4.4)	1.20 (0.73-1.98)
Use of psychotropics, yes	525 (37.0)†	1.33 (1.22-1.45)	283 (19.9)†	1.33 (1.17-1.52)	57 (4.0)	1.12 (0.82-1.51)
Urinary incontinence or frequency, yes	702 (36.2)†	1.35 (1.25-1.47)	403 (20.8)†	1.53 (1.35-1.73)	82 (4.2)	1.24 (0.94-1.65)
Absence of habitual exercise, yes	975 (33.7)†	1.31 (1.20-1.43)	561 (19.4)†	1.58 (1.38-1.81)	110 (3.8)	1.06 (0.80-1.41)
Use of slippers or sandals, yes	415 (36.3)†	1.27 (1.16-1.39)	185 (16.2)	0.99 (0.85-1.14)	63 (5.5)†	1.73 (1.28-2.32)
Use of walking aid, yes	887 (36.7)†	1.49 (1.37-1.63)	492 (20.3)†	1.60 (1.41-1.82)	109 (4.5)†	1.51 (1.14-2.01)

*p < .05, †p < .01, ‡Mean ± standard deviation.

Statistical analysis

Each SRRST item and potential confounding factor was compared between the participants with and without a single fall, recurrent falls, and fall-related fractures using *t*-tests for age and chi-square tests for categorical variables. Odds ratios (ORs) of potential risk factors were also calculated for categorical variables.

Multiple logistic regression analysis was performed to explore the independent associations between total SRRST score and falls and fall-related fractures with potential confounding factors. Multiple logistic regression models included total SRRST score as an independent variable, which was categorized into no risk (0 point), low risk (1 to 2 points), moderate risk (3 to 4 points), and high risk (≥ 5 points). The SRRST categories were assessed by their P-values for trend and were used to calculate the OR and 95% confidence interval (95% CI) relative to the category of 'no risk' for each higher category. Covariates were added sequentially to the logistic model to evaluate the associations at different levels of adjustment. Model 1 included the SRRST category plus age and sex, and model 2 included the model 1 variables plus other possible confounding factors. The participants were divided into dependent walking and independent walking groups for subgroup analysis. Logistic regression analysis (model 2) was performed in each group. The validity of the model was quantified using the C-Index and Hosmer-Lemeshow statistic for goodness of fit. Sensitivity and specificity statistics were used to determine the ability of classification in the SRRST. Sensitivity and specificity for falls and fall-related fractures were calculated in each SRRST score. Cut-points for maximizing the sensitivity and specificity for each score were determined using the closest-to-(0, 1) criterion [25]. All data management and statistical computations were performed using the SPSS 17.0 software package (SPSS Inc., Chicago, IL, USA).

Results

The participants were recruited from 88 TOUCH demonstration sites (35% of all sites) and completed the investigation. About 65% of the TOUCH sites (about 19,800 elderly people) could not complete the investigation. Table 2 shows the characteristics of the participants (Table 2).

Table 2 Characteristics (number and percent) of the participants (n = 5,062)

Age*	83 (41)
Women	3,541 (70.0)
Single fall during a one-year period	1,536 (30.3)
Recurrent falls during a one-year period	828 (16.4)
Fall-related fracture during a one-year period	188 (3.7)
Femoral fracture	74 (1.5)
Fracture of the skull, trunk, pelvic, and lower legs	68 (1.3)
Fracture of the arms	46 (0.9)
Stroke	1,077 (21.3)
Knee osteoarthritis with pain	1,798 (35.5)
Dementia	1,953 (38.6)
Poor vision	630 (12.4)
Parkinson disease	365 (7.2)
Use of psychotropics	1,420 (28.1)
Urinary incontinence or frequency	1,941 (38.3)
Absence of habitual exercise	2,889 (57.1)
Use of slippers and sandals	1,144 (22.6)
Use of a walking aid	2,418 (47.8)
Mobility status	
Independent gait	2,930 (57.9)
Independent transfers	953 (18.8)
Independent sit up	589 (11.6)
Dependent sit up	590 (11.7)

* median (range).

Number of participants with falls and fall-related fractures

Of the 5,062 elderly people, 1536 (30.3%) reported a single fall in the previous year, 828 (16.4%) had recurrent falls, and 188 (3.7%) experienced fall-related fractures. Of the participants with fractures, 74 (39.4%) had a femoral fracture, 68 (36.2%) participants had a fracture of the skull, trunk, pelvic, or lower leg, and 46 (24.5%) experienced a fracture of the arm.

Comparison between participants with and without falls and fall-related fractures

All SRRST items showed significant differences between those with and without a fall, recurrent falls, and fall-related fractures. In terms of potential confounding variables, there were significant differences for all except history of stroke when single fallers and non fallers were compared. When recurrent fallers were compared with non-recurrent fallers there was a significant difference for all potential confounders except for history of stroke and daily use of slippers or sandals. Compared with participants without fractures, those with fractures were significantly more likely to report daily use of slippers or sandals or use of walking aids (Table 1).

Among the SRRST items, ORs of the participants with risk to those without risk were 1.66 to 2.21 for a single fall, 2.16 to 3.55 for recurrent falls, and 1.49 to 2.18 for fall-related fractures. The ORs of significant confounders were 1.23 to 1.53 for a single fall, 1.32 to 1.85 for recurrent falls, and 1.51 to 1.73 for fall-related fractures. The highest ORs for a single fall, recurrent falls, and fall-related fractures were recognized for the SRRST items of risk of falls during walking, stair ascending/descending, and wandering, respectively (Table 1).

Risk factors for falls

The multiple logistic regression models showed significant relationships between falls and fall-related fractures and SRRST categories (Table 3). Participants who had higher fall risk on the SRRST had higher rates of falling and fall-related fractures (Figure 1). In model 1, which adjusted for age and sex, the OR for a single fall, recurrent falls, and fall-related fractures increased as the SRRST score increased, and P for trend of all models showed significance. The ORs of the high-risk group compared with the no-risk group were 7.56 (95% confidence interval (95% CI); 6.07-9.42) for single fall; 17.71 (95% CI; 12.32-25.45) for recurrent falls, and 4.65 (95% CI; 2.73-7.94) for fall-related fractures (P for trend < 0.01). The results remained essentially unchanged after controlling for other confounders (Table 3, model 2). The highest ORs of factors related to single fall, recurrent falls, and fall-related fractures were for the high-risk group in the SRRST in all logistic models. The p-values of the Hosmer-Lemeshow statistics were > 0.05 in both logistic models (p = 0.12-0.72) and the C-index showed moderate model-fit in nearly all cases (0.67-0.74). In the subgroup analysis, the significant odds ratios remained essentially the same in the dependent walking and independent walking groups, with the exception of fall-related fracture. Regarding fall-related fractures in the dependent walking group, there were no significant odds ratios when the low and moderate risk groups were compared to the no-risk group of the SRRST (Figure 2).

Sensitivity and specificity

Table 4 shows the sensitivity and specificity of each SRRST score for falls and fall-related fractures. Cut-points for maximizing the sensitivity and specificity were 2/3 point in all of a single fall, recurrent falls and fall-related fractures. Sensitivity and specificity of 2/3 cut-point in a single fall, recurrent falls and fall-related fractures were 0.66 and 0.63, 0.75 and 0.60, and 0.68 and 0.55, respectively.

Discussion

There are many distinct and multifactorial causes for falls in elderly people, including low muscle strength, balance and gait disturbances, cognitive function decline, environmental hazards, and low or high activity levels. Objective measures such as physical tests can provide

Table 3 Odds ratios for falls and fall-related fractures by SRRST category and confounders

	Single fall		Recurrent falls		Fractures	
	Model 1 Odds ratio (95% CI)	Model 2 Odds ratio (95% CI)	Model 1 Odds ratio (95% CI)	Model 2 Odds ratio (95% CI)	Model 1 Odds ratio (95% CI)	Model 2 Odds ratio (95% CI)
Subjective risk rating of specific tasks						
No risk, 0 points	1.00‡	1.00‡	1.00‡	1.00‡	1.00‡	1.00‡
Low risk, 1-2 points	2.65 (2.14-3.28)†	2.40 (1.94-2.98)†	4.17 (2.88-6.06)†	3.88 (2.67-5.64)†	1.80 (1.03-3.15)*	1.77 (1.01-3.12)*
Moderate risk, 3-4 points	5.06 (4.11-6.23)†	4.21 (3.39-5.23)†	9.11 (6.36-13.05)†	7.94 (5.5-11.47)†	3.24 (1.91-5.48)†	3.22 (1.86-5.57)†
High risk, ≥ 5 points	7.56 (6.07-9.42)†	6.15 (4.85-7.8)†	17.71 (12.32-25.45)†	15.04 (10.29-22)†	4.65 (2.73-7.94)†	5.05 (2.83-9.03)†
P for trend	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Potential confounding factors						
Age, years	1.01 (1.00-1.01)	1.01 (1.00-1.02)	1.01 (0.99-1.02)	1.00 (0.99-1.02)	1.02 (1.00-1.05)*	1.03 (1.01-1.05)*
Sex, female	0.97 (0.84-1.11)	0.94 (0.81-1.09)	0.91 (0.77-1.08)	0.89 (0.74-1.06)	1.72 (1.19-2.50)†	1.76 (1.20-2.58)†
History of stroke with symptoms of hemiparesis		1.04 (0.88-1.22)		0.88 (0.72-1.08)		1.32 (0.91-1.93)
Knee osteoarthritis with pain		1.28 (1.12-1.47)†		1.31 (1.11-1.54)†		1.00 (0.73-1.37)
Parkinson disease		1.44 (1.14-1.81)†		1.51 (1.16-1.96)†		1.10 (0.64-1.88)
Dementia		0.93 (0.81-1.08)		0.95 (0.80-1.14)		0.87 (0.62-1.22)
Poor vision		1.05 (0.87-1.27)		1.00 (0.80-1.25)		0.87 (0.56-1.34)
Urinary incontinence or frequency		1.09 (0.95-1.26)		1.06 (0.89-1.26)		0.96 (0.69-1.34)
Use of psychotropics		1.22 (1.06-1.40)†		1.07 (0.90-1.28)		0.95 (0.68-1.32)
Use of walking aid		1.20 (1.05-1.38)†		1.14 (0.96-1.35)		1.07 (0.78-1.47)
Absence of habitual exercise		1.04 (0.90-1.19)		1.15 (0.96-1.37)		0.81 (0.59-1.12)
Daily use of slippers or sandals		1.23 (1.06-1.43)†		0.81 (0.67-0.98)*		1.67 (1.21-2.30)†
C-index, value (95% CI)	0.68 (0.66-0.70)†	0.70 (0.68-0.71)†	0.72 (0.71-0.74)†	0.74 (0.72-0.75)†	0.67 (0.63-0.71)†	0.69 (0.65-0.73)†
Hosmer-Lemeshow test, p value	0.51	0.48	0.72	0.57	0.72	0.12

*$p < .05$, †$p < .01$.
‡Odds ratios in the SRRST category were calculated in the low, moderate, and high risk relative to the no risk.

accurate information in accordance with the task tested, but predictive validity of these tests are inadequate in frail elderly people with multiple risks of falls. This may be explained by the multifactorial nature of falls, which makes the notion of a single screening tool with excellent predictive accuracy an unrealistic goal. Nordin (2008) reported that staff members' assessment of their residents' fall risk as well as history of previous falls appeared superior to performance-based measures of falls in frail elderly people [13]. We therefore examined the utility of an objective assessment tool to identify useful measures for screening frail elderly people for fall risk.

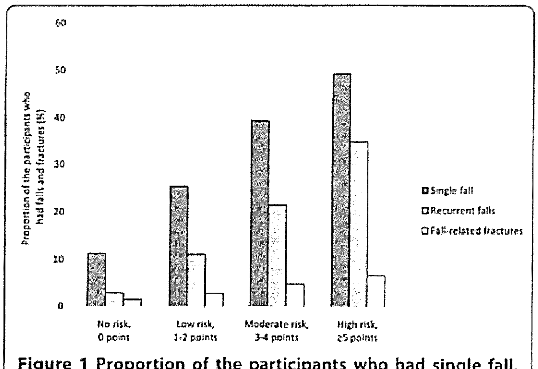

Figure 1 Proportion of the participants who had single fall, recurrent falls, and fall-related fractures according to fall risk. Frail, elderly participants were categorized into four **fall risk** groups by SRRST score. The rate of single fall, recurrent falls, and fall-related fractures increased in accordance with the risk of falls based on the SRRST score.

In the comparative analysis, when compared with non-fallers, participants who had experienced falling were more likely to have a fall risk (with the exception of history of stroke and use of slippers and sandals). In contrast, when compared with those without fall-related fractures, participants who had fall-related fractures did not show significant differences in many potential confounding factors, although all SRRST items showed significant differences. These results suggest that the subjective assessment used in the SRRST was useful to examine the risk of fractures in the frail elderly.