Osteoporos Int (2010) 21:1825–1833
DOI 10.1007/s00198-009-1150-4

ORIGINAL ARTICLE

Incidence and risk factors of falling in ambulatory patients with rheumatoid arthritis: a prospective 1-year study

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Received: 6 September 2009 / Accepted: 12 November 2009 / Published online: 30 January 2010

Abstract
Summary A prospective 1-year study showed that fall incidence was 50% in women with rheumatoid arthritis. Multivariate analysis identified swollen joint count, use of antihypertensives or diuretics, one-leg standing time, and sway area measured by stabilometer as significant parameters associated with falls.
Introduction Patients with rheumatoid arthritis (RA) may be at increased risk of falling because they frequently experience muscle weakness and stiff or painful joints. The aim of this study was to use a prospective design to determine the incidence of falls and their risk factors in women with RA.
Methods Eighty-four women aged 50 and over who had RA were enrolled. The mean age was 64.1 years. We evaluated postural stability, physical performance related to falls, disease activity, muscle volume, and bone density. The occurrence of falls was assessed every month for 1 year. Among 84 patients, 80 completed a 1-year observation.
Results Forty patients (50.0%) reported one or more falls, and two of them (5.0%) had fractures during the follow-up period. The fall group had more swollen joints and took more antihypertensives and/or diuretics. The fall group also had lower postural stability and tended to have reduced physical performance. The one-leg standing time was shorter, and the step-up-and-down test score was lower in the fall group. The sway area was larger in the fall group.
Discussion Multiple logistic regression analysis identified that number of swollen joints, use of antihypertensives or diuretics, shorter time standing on one foot, and the sway area were the most significant parameters associated with falls.
Conclusion We concluded that fall rates in RA patients were higher than in the general population and that balance impairment or side effects of drugs may play a role in increasing the risk of falls.

Keywords Fall · Rheumatoid arthritis · Risk factor

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Introduction

Falls are one of the major health care concerns for older adults, and their impact is a significant public health problem. Annually, about one third of community dwellers over age 65 fall, and half of those will have a repeat fall [1, 2]. Falls are responsible for two thirds of all unintentional deaths due to injury in older adults [3, 4]. Worldwide, adults over 70 years old, particularly females, have significantly higher fall-related mortality than younger people [5]. The severity of fall-related complications also increases with age [6]. Direct and indirect costs associated with falls total $75–100 billion in the USA annually [4].

Falling is a multicausal phenomenon resulting from complex interactions between intrinsic and extrinsic or environmental factors [1, 7–9]. Population-based studies suggest an association between musculoskeletal problems and an increased risk of falls [7, 10, 11]. The fracture risk in a given individual is determined independently by both bone strength and risk of falling.

Accordingly, patients with rheumatoid arthritis (RA) may be at increased risk of falling because they frequently experience muscle weakness and stiff or painful joints [12–15]. A high incidence of fall was reported in patients with RA [14–16]. However, only a few studies have assessed the incidence and risk of falls in patients with RA [13–16]. Patients with RA are at increased risk of fractures relative to the general population. Relative risk in RA compared with the general population has been reported to be 1.5 [17] to 1.73 [18] for hip fractures, 1.48 for proximal humeral fractures, and 1.39 for wrist fractures [1]. It is well known that RA is affected by periarticular and generalized osteoporosis [19, 20].

No prospective study concerning fall incidence in RA has been performed. This study used a prospective design to determine the incidence of falls and to elucidate their risk factors in patients with RA.

Patients and methods

Patients

Subjects were recruited while attending outpatient clinics at Tottori University Hospital, which is a tertiary referral center with 700 beds. Patients were consecutively selected for this study if they had a definitive diagnosis of RA, were between 50 and 84 years old, ambulatory, without dementia or stroke, and had the ability to understand and complete written informed consent. Eighty-seven patients fulfilled these inclusion criteria, and 84 of these agreed to participate. Investigators provided written and verbal explanations of the study and obtained written consent from subjects.

Of the 84 patients, 80 (95%) completed the entire 1-year observation. Of the four patients who dropped out, three did so during the study period and one withdrew due to the onset of dementia. Characteristics of enrolled patients are presented in Table 1. Patients' mean age was 65.2 years old (range, 50–82 years old), and mean duration of disease was 14.9 years (range, 1–56 years). Fourteen patients (17.5%) were taking at least one biologic. Bisphosphonate and 1α(OH)vitamin D were being administered to 44 patients (55.0%) and 28 patients (35.0%), respectively. Regarding ambulatory ability, 69 patients (86%) were able to walk without a walking aid, while 11 patients (14%) were able to walk with a walking aid of some kind. In terms of comorbidities before enrollment, 28 patients had cardiac disease (including hypertension), five had diabetes, three had *thyroid* disease, three had pulmonary disease, three had urinary incontinence, two had another collagen disease, and one had cancer. Eighteen patients (22.5%) had undergone joint surgery on one or more limbs prior to this study. Surgeries included 15 arthroplasties of the upper extremities (12 patients), 23 arthroplasties of the lower extremities (11 patients), five spine surgery (five patients), and two osteosyntheses (two patients; Table 1).

Fall assessment

A fall was defined as the subject unintentionally coming down on the floor or to a lower level [11]. Falls during the 1 year of follow-up were tracked with a "fall calendar." Patients were instructed to check it when they fell [21] and to mail it to our institute each month. If they did not return the card despite a reminder, or if the calendar card was completed incorrectly, they were contacted by telephone.

Patients were divided into two groups after the 1-year observation according to their fall calendar: the fall group (one or more falls) and no-fall group (no fall).

Symptoms and activity of RA

At the beginning of the study, patients were examined and interviewed about general health as well as a detailed RA history, including duration of disease. We obtained the Modified Health Assessment Questionnaire (mHAQ) score and evaluated RA stage and patients' functional class by Steinblocker criteria [22]. Steinblocker stage was assessed based on the status of the most affected joints. Current drug treatment, including administration of glucocorticoids, biologics, bisphosphonate, and 1α(OH)vitamin D were reviewed. The number of tender and swollen joint counts was recorded. RA disease activity was evaluated by joint count (swollen and tender joints), Disease Activity Score (DAS28) (three parameters), erythrocyte sedimentation ratio (ESR) (mm/h), and C-reactive protein (CRP) (mg/dl). Serum 25-hydroxy-vitamin D (25(OH)D) (ng/ml) concentrations were measured by radioimmunoassay (25-hydroxy-vitamin D 125I RIA kit, DiaSorin Inc., Italy).

We evaluated foot deformity with a 0 to 8 scoring system, with 1 point added for every instance, on either foot, of hallux valgus, hammer toe, flat foot, or callus on either foot.

Physical function

Physical performance test

Five physical performance tests related to falls were conducted at the beginning of this study.

Functional reach test (cm) A test of balance conducted by measuring the maximal reach of the dominant arm elevated at a 90° angle relative to the ground [8].

Table 1 Patient characteristics

	Total n=80	Fall group n=40	No-fall group n=40	P value
Age (years)	65.2 (7.7)	66.3 (8.2)	64.2 (7.1)	0.22
Body height (cm)	150.4 (6.5)	150.6 (5.8)	150.3 (7.3)	0.83
Body weight (kg)	51.3 (9.5)	51.6 (9.9)	51.1 (9.2)	0.81
BMI (kg/m²)	22.6 (3.5)	22.7 (3.7)	22.6 (3.4)	0.89
Duration of RA (years)	14.9 (11)	16.4 (11.5)	13.4 (10.4)	0.22
25(OH)D (ng/ml)	21.7 (3.1)	21.7 (3.4)	21.8 (2.9)	0.95
Functional class (n)				
I	10	1	9	0.012[b]
II	48	21	27	
III	22	18	4	
Stage (n)				
0	2	1	1	0.64[b]
I	9	2	7	
II	5	1	4	
III	24	17	7	
IV	40	19	21	
Ambulatory ability (n)				
Without aids	69	33	36	0.52[b]
With aids	11	7	4	
Cormobidities (n)				
Cardiac disease including hypertension	28	17	11	0.24[a]
Diabetes	5	4	1	0.36[a]
Thyroid disease	3	2	1	0.99[a]
Pulmonary disease	3	1	2	0.99[a]
Urinary incontinence	3	3	0	0.24[a]
Collagen disease	2	0	2	0.49[a]
Cancer	1	0	1	0.99[a]
Operations (n)				
Upper limb arthroplasty	12	7	5	0.76[a]
Lower limb arthroplasty	11	8	3	0.19[a]
Spine surgery	5	3	2	0.99[a]
Osteosynthesis	2	0	2	0.49[a]
Lower limbs	13	10	3	0.05[a]
Drug intake				
Glucocorticoid (n)	27	19	8	0.02[a]
Glucocorticoid dose (mg/day)	1.9	2.2	1.7	0.34[b]
1α(OH)vitaminD (n)	28	17	11	0.5[a]
Bisphosphonate (n)	44	24	20	0.24[a]
Antihypertensives/diuretics (n)	22	17	5	0.002[a]
Hypnotics/minor tranquilizers (n)	12	9	3	0.06[a]

SD are presented in parenthesis

Significant differences were evaluated by t test except [a] chi-square test, [b] Mann–Whitney U test

Maximum step length (cm) The maximum stride length measured when the patient successfully took as large a step forward as possible with one leg, then immediately followed with the other leg so as to stand straight and still, according to the Good Walker's Index (Kenkyakudo™, Mutoh) [23].

Five-meter walk time Time required to walk 5 m at normal speed. Patients were asked to walk 9 m at normal speed, and measurement was performed over a distance of 5 m (between the 2- and 7-m points). A 2-m approach distance and an additional 2 m beyond the desired 5-m distance ensured that the walking speed was constant across the entire 5 m. We modified Obuchi's method [24] and Tiedemann's methods [25].

Step-up-and-down test A leg strength test in which patients were asked to step up onto and down from stools 20 and 40 cm high, using a five-point grading scale: (1) unable to step up onto (or down from) the 20 cm stool; (2) able to step up onto (or down from) the 20-cm stool, although unsteady on his/her feet; (3) able to easily step up onto (or down from) the 20-cm stool, but not the 40-cm stool; (4) able to step up onto (or down from) the 40-cm stool, although unsteady on his/her feet; (5) able to easily step up onto (or down from) the 40-cm stool, according to the Good Walker's Index (Kenkyakudo™, Mutoh) [23].

One-leg standing test (OLST) (s) The length of time a patient was able to stand on one leg. We asked patients to stand on one leg for as long as possible with both arms resting by their sides, and measurement was performed for each leg. The total measurement values for both legs were recorded [24, 26].

Grip strength (kg) Grip strength was measured using a dynamometer for each hand. Patients were asked to stand upright with both arms by their sides during measurement. The total measurement values for both hands were recorded. When it was impossible to perform measurement due to a deformed hand, 0 kg was recorded.

Physical activity

Physical activity was accessed using an electric pedometer, Lifecorder™ (Suzuken Co., Ltd., Nagoya, Aichi, Japan). This device uses a solid-state medical-grade sensor and digital filtering to deliver extremely accurate results regarding day-to-day activity. The Lifecorder™ filters out motion and vibration artifacts, counting only actual steps. It also measures the intensity of physical activity and accurately records how much time is spent at moderate or greater intensity levels. Total calories (kcal), activity calories (kcal), and steps (steps) were recorded for 2 weeks and automatically averaged over 12 days (the first and last days were excluded) based on age, gender, body weight, and body height. Data were recorded from April to October, so all patients were assessed during the same time of year to the greatest degree possible. Activity calories were calculated based on energy expenditure associated with movement locomotion such as walking or running (http://www.suzuken.co.jp/english/whats/closeup/diabetes02.html).

Standing balance

The patient stood on a force sensor plate with the feet shoulder-width apart for 60 s with eyes open. Using a stabilometer (Etude Bar Ex, Hitachi Plant Technologies, Co., Ltd., Tokyo, Japan), the locus of the center of foot pressure was recorded at the beginning of this study. Total path length (centimeters) and area surrounded by locus (square centimeters) were measured automatically.

Bone mineral density and muscle and fat volume

Measurement of bone mineral density (BMD) was performed using dual-energy X-ray absorptiometry (model QDR 4500A instrument: Hologic, Waltham, MA) at the beginning of this study. BMD (gram per square centimeters) of the total hip was measured.

Paravertebral muscle width (millimeters) was measured by computed tomography (CT) scans at mid-abdomen (umbilicus level). Thigh muscle areas (square centimeters) were also evaluated by CT scan at mid-femur level (TXA-101A, Toshiba Medical Systems Corporation, Tokyo).

Statistical analysis

All data are expressed as means ± SD. Differences between means of two groups were assessed with unpaired t tests for parametric values and with Mann–Whitney U test for nonparametric values. Categorical variables were analyzed using chi-square tests.

Multivariate analysis was performed in addition to univariate analysis. Variables with a significance level of $p<0.05$ as determined by univariate analysis were selected for multivariate analysis. Multivariate logistic regression analysis was used to provide adjusted odds ratio estimates for associations with falls.

Statistical analysis was performed using StatView software (Version 5.0; SAS Institute Inc., Cary, NC, USA), and a p value <0.05 was considered statistically significant.

This study was approved by the local ethics committee at the Faculty of Medicine, Tottori University (No. 640).

Results

Incidence of falls and fractures

Forty of 80 patients (50.0%) fell during the observational period (fall group), and 26 of them (32.5%) fell two or more times. Two patients (5.0%) sustained fractures during the period, one at the distal femur 6 months after enrollment and the other at the proximal humerus 9 months after enrollment. We ceased evaluating falls in the patient with the distal femoral fracture after the trauma.

With regard to monthly variation, falls occurred 10 times in 10 patients in January, 11 times in 11 patients in February, six times in four patients in March, 13 times in 11 patients in April, four times in four patients in May, six times in six patients in June, 13 times in 11 patients in July, five times in three patients in August, 12 times in nine patients in September, 10 times in six patients in October, 11 times in 10 patients in November, and five times in five patients in December.

Comparison between the fall and no-fall groups

Patient characteristics and disease activity

Characteristics of patients in the fall and no-fall groups are presented in Table 1. There was no significant difference between the two groups in age, body height, body weight, BMI, duration of RA, and 25(OH)D serum level. In the fall group, functional class was more advanced (p=0.012), and more patients took antihypertensives and/or diuretics than in the no-fall group (p=0.002). The number of patients taking glucocorticoid was higher in the fall group (p=0.02), but there was no significant difference in mean dose between the two groups. There was also no significant difference in Steinblocker stage, and number of patients administered biologics, bisphosphonate, or 1α(OH)vitamin D. The number of patients who had undergone surgery of the lower limbs and those who were receiving hypnotics or minor tranquilizers tended to be higher in the fall group than the no-fall group (p=0.05 and p=0.06, respectively; Table 1).

The total swollen joint count at enrollment was significantly higher in the fall group than the no-fall group (p= 0.008; Table 2). The mHAQ score at enrollment was also significantly higher in the fall group than the no-fall group (p=0.03). There was no significant difference between the two groups in number of swollen joints in the lower limbs, number of tender joints, DAS28, CRP, ESR, or foot deformity score (Table 2).

Physical performance, physical activity, and body balance

The results of the physical function test and assessments of physical activity are presented in Table 3. One-leg standing time was significantly shorter in the fall group than in the no-fall group (p=0.008). The mean step-up-and-down test score in the fall group was lower than in the no-fall group (p=0.02). There was no significant difference in other physical performance test results between the two groups. There was no significant difference between the fall and no-fall groups in the physical activities evaluated by Lifecorder™, such as averaged activity calories, averaged total calories, and averaged steps. Regarding the standing balance measurement by stabilometer, the area surrounding path length was significantly larger in the fall group than the no-fall group (p=0.003; Table 4).

BMD and muscle volume

There was no significant difference in BMD of the femur between the fall and no-fall groups (Table 4). Muscle area of the lower limb and width of the trunk showed no significant difference between the fall and no-fall groups (Table 4).

Multivariate logistic regression analysis

Multivariate analysis included risk factors determined by univariate analysis to have a significance level of p<0.05 (Table 5). Functional class, mHAQ, and step-up-and-down test scores were divided into two categories based on median value. Functional class was categorized as 0 (classes 1 and 2) or 1 (class 3), mHAQ scare as 0 (0–3) or 1 [4–13], and step-up-and-down test score as 0 [1–4] or 1 [5]. One-leg standing time was categorized as 0 (<60 s) or 1 (≥60 s). In the multivariate analysis, swollen joint count,

Table 2 Swollen and tender joint count, joint deformity, and inflamation data

	Total	Fall group	No-fall group	*P* value
Swollen joint count (total joints)	4.68 (5.45)	6.28 (6.86)	3.08 (2.80)	0.008
Tender joint count (total joints)	3.74 (6.04)	4.30 (7.02)	3.18 (4.88)	0.41
Swollen joint count (lower limbs)	0.96 (1.68)	1.08 (1.90)	0.55 (0.88)	0.12
Tender joint count (lower limbs)	1.40 (3.00)	1.90 (3.67)	0.88 (1.76)	0.12
mHAQ (score)[a]	0.38	0.50	0.13	0.03[b]
DAS28-ESR	4.33 (0.93	4.40 (0.97)	4.30 (0.95)	0.64
CRP (mg/dl)	1.55 (1.73)	1.38 (1.48)	1.72 (1.95)	0.38
ESR (mm/h)	55.2 (27.1)	53.5 (27.3)	57.1 (27.0)	0.56
Deformity score of both feet[a]	2	2	2	0.69

Data are mean (SD)

[a] Median

Significant differences were evaluated by *t* test except [b] Mann–Whitney *U* test

Table 3 Physical performance and physical activity

	Total	Fall group	No-fall group	*P* value
Functional reach test (cm)	32.5 (6.9)	31.1 (6.5)	34.0 (7.1)	0.06
Maximum step length (cm)	87.1 (18.1)	83.7 (16.5)	90.5 (19.5)	0.09
5-Meter walk time (s)	4.53 (1.34)	4.75 (1.49)	4.34 (1.15)	0.14
One-leg standing test (s)[a]	25.8	17.8	44.3	0.008[b]
Grip power of both hands (kg)	16.1 (10.0)	14.2 (8.7)	18.2 (10.9)	0.07
Step-up-and-down test[a]	4	4	5	0.02[b]
Average energy expenditure (kcal)	110 (67)	119 (76)	102 (58)	0.28
Average total energy expenditure($\times 10^3$) (kcal)	1.5 (0.17)	1.5 (0.16)	1.5 (0.17)	0.81
Average steps ($\times 10^3$)	6.1 (3.8)	6.1 (3.7)	6.0 (4.0)	0.89

Data are mean (SD)

[a] Median

Significant differences were evaluated by *t* test except [b] Mann–Whitney *U* test

antihypertensives/diuretics, one-leg standing time, and area surrounding path length (square centimeters) were determined to be significant risk factors. mHAQ was tended to be a risk factor.

Discussion

In this prospective study, 40 of 80 patients (50%) aged 50 years and over with RA reported falls during the 12-month study period. This is the first report to ascertain the incidence of falls in patients with RA using a prospective observational study design. The fall incidence among members of the general Japanese population aged 65 years and over is reported to be between 10% and 20% [24, 27, 28]. In comparison with this more general data, the incidence of falls in patients with RA is considerably higher.

A few retrospective studies have examined the fall incidence in RA patients and have reported it to range from 30% to 50% over 1 year [14–16]. A study in England retrospectively evaluated the incidence of falls by interviewing 253 rheumatoid patients aged 35 years and over, with a mean age of 62 years, and found that 33% reported a fall (36% of women) during the previous 12 months [14]. The authors concluded that falls were associated with self-reported impairment in lower limb function. Another retrospective study showed that 76 of 155 patients (49%) with a mean age of 59.7 years reported a fall during the previous 12 months [15]. A case-control study showed that more women with RA gave a history of a previous fall compared with women with postmenopausal osteoporosis (54% vs. 44%) [16]. These rates are the same or slightly lower than that observed in the current study. Retrospective studies tend to underestimate the incidence of falls when compared to data derived from a prospective study [14]. Our study was designed to evaluate the occurrence of falls prospectively, with an attempt to further increase accuracy by using a fall calendar and contacting patients every month.

This should be considered a pilot study because little is known about the occurrence of falls and risk factors in RA patients. Previous studies have identified arthritis as a risk factor for falls [12–16]; however, the nature of the underlying arthritis was not specified. In this study, to assess the specific risk for falls in individuals with RA, many variables were examined.

Eight variables differed significantly between the fall and no-fall groups. Among these, we determined that swollen joint count, administration of antihypertensives and/or diuretics, one-leg standing time, and area surrounding path length were independent risk factors.

Falls among community-dwelling elderly persons have been associated with medication use, advanced age, specific diseases such as stroke, urinary incontinence, and cardiovascular disease, and physical disabilities such as muscle weakness, abnormalities of gait or balance, and joint disorders [1, 2, 7, 11, 29–31]. Physical disability was significantly more severe in RA patients who fell, and this is in accordance with previous studies [14–16].

Administration of antihypertensives and/or diuretics may affect body balance in both elderly and RA patients.

Table 4 Body sway test by stabilometer, bone mineral density, and muscle area

	Total	Fall group	No-fall group	*P* value
Total path length (cm)	82.19 (33.10)	87.10 (33.25)	77.41 (32.66)	0.19
Area surrounded by locus (cm^2)	2.52 (1.76)	3.10 (2.03)	1.96 (1.23)	0.003
Femoral neck BMD (g/cm²)	0.73 (0.13)	0.72 (0.13)	0.74 (0.14)	0.63
Body fat percentage (%)	30.77 (5.75)	29.82 (5.54)	31.71 (5.86)	0.14
Muscle area of lower limb ($\times 10^4$) (mm²)	0.91 (0.26)	0.95 (0.25)	0.87 (0.26)	0.2
Width of paravertebral muscle (mm)	30.23 (5.88)	30.46 (6.64)	29.97 (5.00)	0.72

Data are mean (SD)

Significant differences were evaluated by *t* test

Table 5 Selected risk factors for fall by multivariate analysis

	Odds ratio	%95 IC	*P* value
Class[a]	2.25	(0.55–9.22)	0.26
Glucocorticoid intake	0.55	(0.15–2.10)	0.39
mHAQ[b]	3.28	(0.87–12.34)	0.08
Swollen joint count	1.26	(1.06–1.50)	0.01
Antihypertensives/diuretics intake	9.22	(1.87–45.41)	<0.01
One-leg standing time[c]	0.17	(0.03–0.86)	0.03
Step-up-and-down test[d]	2.13	(0.50–9.16)	0.31
Area surrounded by locus	1.8	(1.15–2.83)	0.01

Variables for multivariate analysis were selected by univariate analysis using a significance level of $p<0.05$

[a] Class was categorized as 0:1,2 and 1:3

[b] mHAQ was categorized as 0:<0.4 and 1:≥0.4

[c] One-leg standing time was categorized as 0:<60 and 1:≥60

[d] Step-up-and-down test was categorized as 0:1–4 and 1:5

Diuretics used to treat high blood pressure can reduce blood volume by removing fluid from the body. Especially potent diuretics given in high doses are a common cause of orthostatic hypotension. Some conditions cause orthostatic hypotension by dilating arterioles and veins. Drugs that dilate arterioles (vasodilators) can cause orthostatic hypotension. These include nitrates, calcium channel blockers, angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, alpha blockers, alcohol, and antidepressants. It has been reported that the odds ratio (OR) of association of falls with hypotensive diuretics was 2.39 in patients in an academic hospital (95% CI 1.42–3.95) [32] and that that of recurrent falls with hypotensive diuretics in a general elderly population was 1.6 (95% CI 1.1–2.3) [11]. With regard to RA patients, the OR of association of falls with diuretics was 1.79 (95% CI 0.9–3.59) [15].

Subjects performed six physical performance tests. Falls correlate with immobility, abnormal balance, and poor physical state. The literature on fall prevention shows that poor performance on every one of the six tests has been linked to falls. In this study, the fall group tended to perform more poorly on all tests. The two groups differed most with regard to OLST and step-up-and-down test; moreover, low OLST scores were a significant risk factor.

Static balance, as evaluated by a stabilometer, tended to be more impaired in the fall group than the no-fall group. The sway area was larger and was a significant risk factor for falls. This was the same in accordance with previous studies in community-dwelling elderly women [33, 34].

A significant risk factor for RA patients was swollen joint count, which is supported by previous studies that identified musculoskeletal problems as risk factors for falls [13, 14, 16]. Joint swelling and pain, both objective signs of joint inflammation, may affect dynamic balance or muscle strength, resulting in increased risks of falls.

The mHAQ is an important tool for predicting the prognosis of RA. A recent retrospective study showed a significant relation between mHAQ score and risk of falls [35] whereas another showed no such correlation [15]. In the present study, mHAQ score was not a significant risk factor for falls in multiple regression analyses, which may be explained by the fact that five out of eight categories in the mHAQ deal with function of the upper limbs.

Age is considered to be one of the most important risk factors for falls in the elderly [29, 30, 36]. Muscle volume decreases with age [37, 38], and muscle volume correlates with muscle power [39, 40]. Muscle power and volume correlate with gait speed [41] and gait ability [42]. Therefore, sarcopenia is most likely one of the specific risk factors for falls in RA patients. However, neither age nor muscle volume showed any relation to fall risk in patients with RA in this study. In RA, joint disorders and gait disturbance due to chronic joint pain and swelling seem to play more of a role than age and muscle volume. Chronic pain and swelling may cause immobility and muscle weakness.

Interventions to prevent falls significantly reduce the proportion of older people who fall at least once and the monthly rate of falling. Among the interventions studied in the systematic review and meta-analyses, a multifactorial falls risk assessment and management program was the most effective component [43]. However, it is not clear whether the interventions used to decrease incidence of falls in older women could apply to patients with RA. Potential interventions for women with RA include control of disease activity, rehabilitation or exercise therapy, and balance training. Since impaired body balance due to joint disorders was associated with an increased risk of falls, control of disease activity from the time of RA onset is essential to reduce the risk of falls and the burden of fracture. Recent novel advances in the development of medications have dramatically changed the treatment of RA, and it has become possible to reduce disease activity significantly during its early stages. It is hoped that these treatments might help reduce the risk of falls and fractures.

Our study has several limitations. First, we did not include a control group of non-rheumatoid subjects and, therefore, cannot comment directly on whether RA per se is linked to an increased risk of falls. However, based on our review of the literature, the incidence of falls in RA seems to be substantially higher than that in the general population. Second, falls were confirmed based on interviews, and this might introduce some bias related to fall incidence. Third, the small number of patients enrolled in the tertiary referral center may possibly have affected the results. Since this study was designed as a prospective observation with numerous clinical parameters, the number of patients was limited. Further prospective studies with a larger number of patients evaluating more selected clinical parameters are needed to confirm the results of this study.

In conclusion, it was determined that swollen joint count, administration of antihypertensives and/or diuretics, one-leg standing time, and sway area were independent risk factors for falls in patients with RA. Since we found that impaired body balance due to joint disorders was associated with increased risk of falls in RA patients, control of disease activity as early as possible and careful consideration of total drug burden as well as drug–drug interaction are essential to reducing the risk of falls and the complication of fractures.

Acknowledgements This study was partially supported by a Grant-in-Aid from the Ministry of Education, Culture, Sports, Science, and Technology of Japan (No. 20591778). The authors thank Yusuke Yamasaki Yasunori Kumono Jun-ichi Kishimoto and Toshio Sako for their help and support.

Conflicts of interest None.

References

1. Tinetti ME, Speechley M, Ginter SF (1988) Risk factors for falls among elderly persons living in the community. N Engl J Med 319(26):1701–1707
2. Blake AJ, Morgan K, Bendall MJ, Dallosso H, Ebrahim SB, Arie TH, Fentem PH, Bassey EJ (1988) Falls by elderly people at home: prevalence and associated factors. Age Ageing 17(6):365–372
3. Baker SP, Harvey AH (1985) Fall injuries in the elderly. Clin Geriatr Med 1(3):501–512
4. Moreland J, Richardson J, Chan DH, O'Neill J, Bellissimo A, Grum RM, Shanks L (2003) Evidence-based guidelines for the secondary prevention of falls in older adults. Gerontology 49(2):93–116
5. Peden M, McGee K, Sharma G (2002) The injury chart book: a graphical overview of the global burden of injuries. World Health Organization, Geneva
6. O'Loughlin JL, Robitaille Y, Boivin JF, Suissa S (1993) Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. Am J Epidemiol 137:342–354
7. Nevitt MC, Commings SR, Kidd S, Black D (1989) Risk factors for recurrent nonsyncopal falls: a prospective study. JAMA 261:2663–2668
8. Stalenhoef PA, Diederiks JPM, Knottnerus JA, Kester ADM, Crebolder HFJM (2002) A risk model for the prediction of recurrent falls in community-dwelling elderly: a prospective cohort study. J Clin Epidemiol 55:1088–1094
9. Wild D, Nayak US, Issacs B (1981) Description, classification and prevention of falls in old people at home. Rheumatol Rehabil 20:153–159
10. Leveille SG, Bean J, Bandeen-Roche K, Jones R, Hochberg M, Guralink JM (2002) Musculoskeletal pain and risk for falls in older disabled women living in the community. J Am Geriatr Soc 50:671–678
11. Tromp AM, Smit JH, Deeg DJH, Bouter LM, Lips P (1998) Predictors for Falls and fractures in the longitudinal aging study Amsterdam. J Bone Miner Res 13:1932–1939
12. Karen DF (1997) N. Correlates of fear of falling and activity limitation among persons with rheumatoid arthritis. Arthritis Care Res 10:222–228
13. Jamison M, Neuberger GB, Miller PA (2003) Correlates of falls and fear of falling among adults with rheumatoid arthritis. Arthritis Rheum 49:673–680
14. Kaz Kaz H, Johnsin D, Kerry S, Chinappen U, Tweed K, Patel S (2004) Fall-related risk factors and osteoporosis in women with rheumatoid arthritis. Rheumatology (Oxford) 43:1267–1271
15. Armstrong C, Swarbrick CM, Pye SR, O'Neil TW (2005) Orrurrence and risk factors for falls in rheumatoid arthritis. Ann Rheum Dis 64:1602–1604
16. Brand C, AW J, Lowe A, Morton C (2005) Prevalence outcome and risk for falling in 155 ambulatory patients with rheumatic disease. APLAR J Rheum 8:99–105
17. Kanis JA, Borgstrom F, De Laet C, Johansson H, Johnell O, Jonsson B, Oden A, Zethraeus N, Pfleger B, Khaltaev N (2005) Assessment of fracture risk. Osteoporos Int 16:581–589
18. Hooyman JR, Melton LJ 3rd, Nelson AM, O'Fallon WM, Riggs BL (1984) Fractures after rheumatoid arthritis. A population-based study. Arthritis Rheum 27:1353–1361
19. Roland FJM, van Piet LCM (1992) Bone mass in patients with rheumatoid arthritis. Ann Rheum Dis 51:826–832
20. Gough AK, Lilley J, Eyre S, Holder RL, Emery P (1994) Generalised bone loss in patients with early rheumatoid arthritis. Lancet 8914:3–4
21. Tromp AM, Pluijm SMF, Smit JH, Deeg DJH, Bouter LM, Lips P (2001) Fall-risk screening test: A prospective study on predictors for falls in community-dwelling elderly. J Clin Epidemiol 54:837–844
22. Steinbrocker O, Traeger CH, Batterman RC (1949) Therapeutic criteria in rheumatoid arthritis. JAMA 140:659–662
23. Koh W, Kamioka H, Mutoh Y (2002) The association between socioeconomic characteristics and mobility of the elderly. Shintai kyoiku igaku kenkyu 3:4–17, in Japanese
24. Obuchi S, Shibata H, Yasumura H, Suzuki T (1994) Relationship between walking ability and risk of falls in community dwelling elderly in Japan. J Phys Ther Sci 6:39–44
25. Tiedemann A, Shimada H, Sherrington C, Murray S, Lord S (2008) The comparative ability of eight functional mobility tests for predicting falls in community-dwelling older people. Age Ageing 37:430–435
26. Park H, Kim KJ, Komatsu T, Park SK, Mutoh Y (2008) Effect of combined exercise training on bone, body balance, and gait ability. J Bone Miner Metab 26:254–259
27. Yasumura S, Haga H, Nagai H, Shibata H, Iwasaki K, Ogawa Y, Ahiko T, Ihara K, Sakihara S (1994) Risk factors for falls among the elderly living in a Japanese rural community. Nippon Koshu Eisei Zasshi 41:528–537, in Japanese
28. Aoyagi K, Ross PD, Davis JW, Wasnich RD, Hayashi T, Takemoto T (1998) Falls among community-dwelling elderly in Japan. J Bone Miner Res 13:1468–1474
29. Rubenstein LZ, Josephson KR (1997) Interventions to reduce the multifactorial risks for falling. Lipponcott-Raven, Philadelphia, pp 309–326
30. Rubenstein LZ (2006) Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing 35:37–41
31. Colo'n-Emeric CS, Pieper CF, Artz MB (2002) Can historical and functional risk factors be used to predict fractures in community-dwelling older adults? Development and validation of a clinical tool. Osteoporos Int 3:1955–1961
32. Tanaka M, Suemaru K, Ikegawa Y, Tabuchi N, Araki H (2008) Relationship between the risk of falling and drugs in an academic hospital. Yakugaku Zasshi 128:1355–1361
33. Brauer SG, Burns YR, Galley P (2000) A prospective study of laboratory and clinical measures of postural stability to predict

community-dwelling fallers. J Gerontol A Biol Sci Med Sci 55:469–476
34. Sturnieks DL, Tiedemann A, Chapman K, Munro B, Murray SM, Lord SR (2004) Physiological risk factors for falls in older people with lower limb arthritis. J Rheumatol 31:2272–2279
35. Furuya T, Yamagiwa K, Ikai T, Inoue E, Taniguchi A, Momohara S, Yamanaka H (2009) Associated factors for falls and fear of falling in Japanese patients with rheumatoid arthritis. Clin Rheumatol 28:1325–1330
36. Wickham C, Cooper C, Margetts BM (1989) Muscle strength, activity, housing and the risk of falls in elderly people. Age Aging 18:47–51
37. Lexell J (1995) Human aging, muscle mass, and fiber type composition. J Gerontol A Biol Sci Med Sci 50:11–16
38. Trappe TA, Lindquist DM, Carrithers JA (2001) Muscle-specific atrophy of the quadriceps femoris with aging. J appl Physiol 90:2070–2074
39. Young A, Stokes M, Crowe M (1985) The size and strength of the quadriceps muscles of old and young men. Clin Physiol 5:145–154
40. Young A, Stokes M, Crowe M (1984) Size and strength of the quadriceps muscles of old and young women. Eur J Clin Invest 14:282–287
41. Bonnefoy M, Jauffret M, Jusot JF (2007) Muscle power of lower extremities in relation to functional ability and nutritional status in very elderly people. J Nutr Health Aging 11:223–228
42. Kim JD, Kuno S, Soma R, Masuda K, Adachi K, Nishijima T, Ishizu M, Okada M (2000) Relationship between reduction of hip joint and thigh muscle and walking ability in elderly people. Tairyokukagaku 49:589–596, in japanese
43. Chang JT, Morton SC, Rubenstein LZ, Mojica WA, Maglione M, Suttorp MJ, Roth EA, Shekelle PG (2004) Interventions for the prevention of falls in older adults: systematic review and meta-analysis of randomised clinical trials. BMJ 328(7441):680, Review