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Inferior physical performance tests in 10,998 men in the MrOS study is associated with recurrent falls

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Abstract

Background: recurrent fallers are at especially high risk for injuries.

Objective: to study whether tests of physical performance are associated with recurrent falls.

Subjects: a total of 10,998 men aged 65 years or above.

Methods: questionnaires evaluated falls sustained 12 months preceding testing of grip strength, timed stand, 6-m walk and 20-cm narrow walk test. Means with 95% confidence interval (95% CI) are reported. $P < 0.01$ is a statistically significant difference.

Results: in comparison to both occasional fallers and non-fallers, recurrent fallers performed more poorly on all the physical ability tests (all $P < 0.001$). A score below -2 standard deviations (SDs) in the right-hand grip strength test was associated with an odds ratio of 2.4 (95% CI 1.7, 3.4) for having had recurrent falls compared with having had no fall and of 2.0 (95% CI 1.3, 3.4) for having had recurrent falls compared with having had an occasional fall.

Conclusion: low performance in physical ability tests are in elderly men associated with recurrent falls.

Keywords: *falls, men, muscle, older people, physical performance tests, recurrent*

Introduction

Thirty per cent of individuals over 65 years fall at least once a year and 15% more often [1, 2]. The incidence of fall increases with age [3–6] so that after age 85, around 60% of community-dwelling women and 33% of men fall annually [7–10]. The incidence is even higher in institutionalised individuals [11, 12]. This is serious as falls confer significant morbidity and mortality [13], accounting for 10% of all emergency department visits by the elderly and 6% of urgent hospitalisations [2]. In addition, most fractures in elderly are associated with falls [10, 13] where the hip fracture is regarded as the most devastating fracture, associated with 15% mortality during the hospitalisation period and 33% during the year following the fracture [14].

Consequently, there is a need to target individuals who will fall recurrently, in order to improve our ability to target fall-preventive interventions [15, 16]. Muscle strength, balance and functional capacities have been recommended as these traits are associated with falls [17–19]. The association between falling and muscle function has been evaluated predominantly in women and in high-risk groups [12], only few reports exist from population-based cohorts of old men [20–22]. Cited studies suggest that tests of physical ability may discriminate fallers and non-fallers [20], but it is currently debated whether similar tests could also discriminate recurrent fallers from occasional fallers.

Therefore, we designed this cross-sectional study with the aim of evaluating whether tests of physical performance and estimates of the level of physical activity could discriminate individuals with a history of recurrent falls from occasional fallers and non-fallers. We hypothesised that recurrent fallers would perform worse than both other groups.

Materials and Methods

The Osteoporotic Fractures in Men (MrOS) International Study is a multi-centre study of community-dwelling men aged 65 or older from three countries. All were recruited and evaluated using similar criteria. To be eligible for the study, the men had to be able to walk without aid and be without bilateral hip replacements. Self-defined racial/ethnic background was recorded. Local ethics committees and institutional review boards at each centre approved the study. All participants gave written informed consent, and the study was performed in accordance with the Declaration of Helsinki.

MrOS Hong Kong includes 2,000 Chinese men of Asian ethnicity aged 65–92 years, enrolled between August 2001 and February 2003 [23]. Stratified sampling was adopted to give 33% of subjects in each of the following age groups: 65–69, 70–74 and ≥75 years. Recruitment notices were placed in housing estates and community centres for the elderly.

The MrOS USA includes 5,995 men aged 65 and older, enrolled from March 2000 to April 2002 in six sites [24]. Each US clinical site designed and customised strategies to enhance recruitment of its population. Common strategies included mailings from the Department of Motor Vehicles, voter registration and participant databases, common senior newspaper features and advertisements and targeted presentations. Of these men, 5,362 were self-described as White, 244 as African American, 191 as Asian, 126 as Hispanic and 71 as other ethnicity.

The MrOS Sweden includes 3,014 men aged 69–81 years where above 99% were Caucasians, enrolled from October 2001 to December 2004 in three sites [25]. Recruitment was done by identifying the men using the national population registers, ending with a participation rate of 45%.

The present report use pooled baseline data in MrOS from all sites. All tests were performed and registered by research nurses or trained research staff according to a standardised protocol. Height and weight were measured using an electric scale or balance beam scale and a Harpender stadiometer. Body mass index (kg/m^2) was calculated as weight divided by height squared.

A Jamar® hydraulic hand dynamometer (5030J1), Jackson, MI, USA, with adjustable hand grip was used in the grip strength measurement. The participant was seated in a standard chair with the arm resting on a moveable table with the dynamometer in an upright position. Two trials of each hand were performed. The better of the two results was used in these analyses, with the result presented in kilograms of force. The measurement was not performed if the subject had current arthritis or pain in the wrist or hand or had undergone fusion, arthroplasty, tendon repair, synovectomy or related surgery of the upper extremity in the 3 months preceding the measurements. The coefficient of variation (CV) was 0.5%.

A straight-backed chair without arms with a seat height of 45 cm was used in the timed stands test. Participants were seated in a position which allowed them to place their feet on the floor with knees flexed to slightly over 90° so that their heels were somewhat closer to the chair than the back of the knees. The arms were crossed over the chest and the rise was from full sitting to standing position. Before the test was initiated, the examiners placed themselves in front of the study participants and demonstrated the procedure visually. The time to complete five chair stand(s) without using the arms was recorded in order to assess the muscle endurance of several large muscle groups. The CV was 2.4%.

In the 6-m walking test and the 20-cm narrow walking test, participants followed a walking course laid out on the floor. In the first test, the participants walked 6 m at their usual pace. The duration of the walk was measured as well as the number of steps. Steps were counted by counting both right and left steps and included the initial starting step and the step that first touched the floor across the finish line. In the 20-cm narrow walking test, the participants walked the 6-m course within a 20-cm narrow path. Two scored trials were performed and the performance was scored for time if there were no more than two deviations from the path. In the USA, up to three tests were performed and two successful tests were required to be included. The best of the results was used. Timing was started when the first footfall crossed over the starting line, that is, when the participant's foot touched the floor on the first step. The timing was stopped when the first footfall crossed the finish line. Time was recorded within 0.1 s in both tests. The CV was 4.9 and 4.8% for the respective tests.

Self-reported falls during the 12 months preceding the measurements were evaluated as a part of the medical history review and level of physical activity as part of the Physical Activity Scale for the Elderly questionnaire [26].

Recurrent fallers were defined as individuals who had more than one fall, occasional fallers as individuals who had one fall and non-fallers as individuals who had no falls during the 12-month period. The questionnaire queried daily walking distance and daily duration of lying down and sitting down, as part of the clinical interview and whether the participants were involved in no, light or moderate physical activity, if they participated in no, recreational or heavy sport activity, if they exercised to maintain or improve muscle strength, if they participated in household activities, including light and heavy household work, home repair, gardening and if they were caring for another person. Occupational activities included paid and unpaid work.

The computer program SPSS was used in the statistical analysis. Data are presented as means with 95% confidence intervals (95% CIs) or proportions (%). Analyses of covariance or logistic regression, with adjustment for age and geographical measuring site, were used to test whether there were differences between frequent fallers, occasional fallers and non-fallers. Age-related Z-scores were calculated within each geographical measuring site. Odds ratios (ORs) were calculated by logistic regression to estimate differences in risk of having sustained a fall in the preceding 12 months, with different subgroups of right-hand grip strength Z-score. Area under curve (AUC) was calculated from the receiver operating characteristic (ROC) curve for the different tests. CV in % was calculated by the formula $CV = SD/mean$ through double measurements within the Swedish MrOS cohort. Due to the multiple comparisons, a *P*-value of <0.01 was regarded as a statistically significant difference.

Results

Fall epidemiology

A total of 2,047 (18.7%) men in MrOS International reported that they had fallen during the 12 months preceding the baseline evaluation, 1,207 (11.0%) once and 842 (7.7%) recurrent times, while 8,928 (81.3%) reported no falls during the same period.

Recurrent fallers versus non-fallers

In comparison with non-fallers, recurrent fallers performed more poorly in all physical ability tests (all *P* < 0.001), they walked less for exercise (*P* < 0.01), spent more time sitting (*P* < 0.001) (Table 1), did no different physical training (Table 1) but were less active in heavy housekeeping (*P* < 0.01) (Table 2). A score below −2 SD in right-hand grip strength test was associated with an OR of 2.4 (95% CI 1.7, 3.4) for having had recurrent falls compared with not having had a fall (Table 3). The ROC curves revealed that even though the physical performance tests significantly discriminated recurrent fallers from non-fallers, the discriminative ability for a specific individual was low with AUC for the tests varying between 0.55 and 0.58. Furthermore, the

Table 1. Anthropometry, physical ability tests and habitual physical activity in recurrent fallers, occasional fallers and non-fallers presented as numbers with proportions or as mean with 95% CI. Significant differences shown in bold.

	Recurrent fallers (a)	Occasional fallers (b)	Non-fallers (c)	Group differences P-value	Adjusted differences a–b	Adjusted differences a–c	Adjusted differences b–c
Numbers	842 (7.7%)	1207 (11.0%)	8928 (81.3%)	—	—	—	—
Age (years)	75.0 (74.7, 75.4)	74.7 (74.3, 75.0)	73.7 (73.6, 73.8)	**<0.001**	0.4 (–0.1, 0.8)	**1.3 (0.9, 1.7)**	**1.0 (0.7, 1.3)**
Anthropometry							
Height (cm)	173.2 (172.7, 173.7)	172.1 (171.7, 172.6)	172.2 (172.1, 172.4)	0.58	–0.1 (–0.6, 0.5)	0.1 (–0.3, 0.6)	0.2 (–0.2, 0.6)
Weight (kg)	80.8 (79.8, 81.7)	78.9 (78.0, 79.7)	78.5 (78.2, 78.8)	0.02	–0.10 (–1.2, 1.0)	0.8 (–0.1, 1.6)	0.9 (0.1, 1.6)
Body mass index (kg/m^2)	26.8 (26.6, 27.1)	26.5 (26.3, 26.7)	26.4 (26.3, 26.4)	0.05	0.0 (–0.3, 0.3)	0.2 (0.1, 0.5)	0.2 (0.0, 0.4)
Physical ability tests							
Right-hand grip strength (kg)	36.3 (35.7, 37.0)	37.0 (36.5, 37.5)	38.6 (38.4, 38.8)	**<0.001**	**–1.3 (–2.0, –0.6)**	**–2.2 (–2.8, –1.7)**	**–0.9 (–1.4, –0.4)**
Left-hand grip strength (kg)	35.1 (34.5, 35.7)	35.4 (34.9, 35.9)	37.0 (36.8, 37.1)	**<0.001**	**–1.1 (–1.7, –0.4)**	**–1.8 (–2.4, –1.3)**	**–0.8 (–1.2, –0.3)**
Timed stands test (s)	12.7 (12.4, 13.1)	12.4 (12.1, 12.6)	11.9 (11.8, 12.0)	**<0.001**	**0.3 (0.0, 0.7)**	**0.8 (0.6, 1.1)**	**0.5 (0.3, 0.7)**
6-m walking test (s)	5.9 (5.7, 6.0)	5.7 (5.6, 5.8)	5.4 (5.4, 5.5)	**<0.001**	**0.3 (0.1, 0.4)**	**0.4 (0.3, 0.6)**	**0.2 (0.1, 0.3)**
Steps needed for 6-m walk (n)	10.3 (10.1, 10.5)	10.1 (10.0, 10,2)	9.7 (9.7, 9.7)	**<0.001**	**0.3 (0.1, 0.4)**	**0.6 (0.5, 0.7)**	**0.3 (0.2, 0.4)**
20-cm narrow walk test (s)	6.6 (6.4, 6.9)	6.4 (6.3, 6.5)	6.1 (6.0, 6.1)	**<0.001**	**0.4 (0.2, 0.6)**	**0.6 (0.4, 0.7)**	**0.2 (0.1, 0.3)**
Habitual physical activity							
Walking for exercise (km)	2.7 (2.5, 2.9)	2.5 (2.3, 2.6)	2.8 (2.8, 2.9)	**<0.01**	–0.1 (–0.3, 0.2)	**–0.2 (–0.4, 0.0)**	**–0.2 (–0.3. 0.0)**
Walking as daily routine (km)	1.1 (1.0, 1.2)	1.1 (1.0, 1.2)	1.1 (1.1, 1.2)	0.04	–0.1 (–0.2, 0.0)	–0.1 (–0.2, 0.0)	0.0 (–0.1, 0.1)
Daily lying (h)	8.3 (8.2, 8.5)	8.3 (8.2, 8.4)	8.2 (8.2, 8.2)	0.10	0.1 (–0.1, 0.2)	0.1 (0.0, 0.2)	0.1 (0.0, 0.1)
Daily sitting (h)	6.4 (6.2, 6.7)	6.5 (6.3, 6.7)	6.1 (6.0, 6.2)	**<0.001**	0.0 (–0.3, 0.2)	**0.3 (0.1, 0.5)**	**0.4 (0.2, 0.5)**

shape of the curves showed no clear cut-off point in any of the ROC curves (figures not shown).

Recurrent fallers versus occasional fallers

In comparison with occasional fallers, recurrent fallers performed worse in all physical ability tests ($P < 0.001$) (Table 1) but were in general at the same level of physical activity as the occasional fallers (Tables 1 and 2). A score below –2 SD in right-hand grip strength test was associated with an OR of 2.0 (95% CI 1.3, 3.4) for being a recurrent faller compared with being an occasional faller (Table 3). The ROC curves revealed that even though the physical performance tests significantly discriminated recurrent fallers from occasional fallers, the discriminative ability for a specific individual was low with AUC for the tests varying between 0.51 and 0.55. Furthermore, the shape of the curves showed no clear cut-off point in any of the ROC curves (figures not shown).

Occasional fallers versus non-fallers

In comparison to non-fallers, occasional fallers performed worse in all physical ability tests (all $P < 0.001$), walked less for exercise ($P < 0.01$), spent more time sitting down ($P < 0.01$) (Table 1), did no different physical training but were

less active in heavy housekeeping ($P < 0.01$) (Table 2). The ROC curves revealed that even though the physical performance tests significantly discriminated recurrent occasional fallers from non-fallers, the discriminative ability for a specific individual was low with AUC for the tests varying between 0.52 and 0.54. Furthermore, the shape of the curves showed no clear cut-off point in any of the ROC curves (figures not shown).

Discussion

Recurrent fallers performed inferiorly to both non-fallers and occasional fallers in evaluated physical ability tests. However, the utility of the test when deciding treatment strategy at the individual level seems low according to the ROC analyses. That it, the differences seems to be of minor clinical significance for on an individual basis identify recurrent fallers. Instead, the tests should predominantly be used in epidemiological studies. There were also indications that not only recurrent fallers but also occasional fallers walked less for exercise, spent more time sitting and were less involved in heavy household activities than non-fallers but that recurrent and occasional fallers were at similar level of habitual physical activity. This indicates that a history of low general physical activity could not be used to

Table 2. Level of physical training and habitual physical activity in recurrent fallers, occasional fallers and non-fallers. Significant differences shown in bold.

	Recurrent fallers (n = 842)	Occasional fallers (n = 1,207)	Non-fallers (n = 8,928)	Group differences P-value
Training history				
Physical training, light; bowling, boules etc.				
Never	72.1%	69.3%	65.2%	0.02
1–2 days/week	13.5%	13.8%	15.9%	
3–4 days/week	8.1%	6.0%	7.7%	
5–7 days/week	6.3%	10.9%	11.2%	
Physical training, moderate; doubles tennis, dance, golf etc.				
Never	80.1%	77.4%	75.6%	0.08
1–2 days/week	12.5%	12.4%	14.1%	
3–4 days/week	5.1%	6.0%	6.7%	
5–7 days/week	2.3%	4.2%	3.6%	
Physical training, heavy; jogging, tennis, swimming, aerobics etc.				
Never	73.2%	71.7%	70.3%	0.22
1–2 days/week	9.8%	8.9%	10.5%	
3–4 days/week	9.8%	10.0%	10.2%	
5–7 days/week	7.2%	9.5%	8.9%	
Strength training				
Never	67.8%	66.1%	69.9%	0.61
1–2 days/week	11.1%	10.2%	10.2%	
3–4 days/week	11.6%	13.0%	11.9%	
5–7 days/week	9.5%	10.7%	8.0%	
Habitual physical activity				
Housekeeping, light; dusting, washing dishes etc.	83.4%	80.9%	82.2%	0.91
Housekeeping, heavy; vacuum-cleaning, window-cleaning etc.	63.9%	63.8%	67.8%	**<0.01**
Home repairs; painting, wallpapering, electricity work etc.	38.9%	35.5%	35.8%	0.81
Moderately heavy garden work; sweeping the yard, rake leaves, shovel snow etc.	57.7%	51.4%	52.9%	0.20
Gardening	45.2%	42.3%	43.0%	0.26
Taking care of another person, i.e. children, spouse other adult	21.0%	19.9%	19.0%	0.18
Working for payment or as volunteer	33.8%	34.1%	33.0%	0.98

Data are presented as proportions. Information of training history are missing in 50 men and of habitual physical activity in 39. Comparison is done by logistic regression with adjustment for age and geographic measuring site. The only group difference found was for heavy housework (recurrent fallers versus non-fallers $P = 0.003$; Recurrent fallers versus occasional fallers $P = 0.21$; occasional fallers versus non-fallers $P = 0.16$).

Table 3. OR for hand grip strength for different Z-score was calculated by logistic regression and presented as mean with 95% CI. Significant differences shown in bold.

Z-score	+2 to +1	+1 to −1 (reference group)	−1 to −2	<−2
Recurrent fallers versus occasional fallers				
Right-hand grip strength	0.9 (0.6, 1.2)	1.0	**1.5 (1.2, 2.0)**	**2.0 (1.3, 3.4)**
Recurrent fallers versus non-fallers				
Right-hand grip strength	**0.8 (0.6, 1.0)**	1.0	**1.6 (1.3, 2.0)**	**2.4 (1.7, 3.4)**
Occasional fallers versus non-fallers				
Right-hand grip strength	0.9 (0.7, 1.1)	1.0	1.1 (0.9, 1.3)	1.1 (0.7, 1.1)

identify recurrent fallers from occasional fallers but to identify any faller from non-fallers.

The total incidence of 18.7% fallers during 1 year is slightly lower than that found in previous studies that reported a fall incidence of 22–29% per year in elderly men [21, 27–30]. The slightly lower fall rate in the MrOS men could be due to the discrepancy in ethnicity and ages included in the different studies, as well as the fact that the men in MrOS were all volunteers who agreed to participate in an extended examination. This might have led the frailest and sickest men to refuse participation. Exclusion of subjects who walked with aids could also exclude the frailest men who are at higher risk of falls, leading to lower falls rates than would be expected across the population. Another limitation is that the proportion of white and non-white participants in the US group was not the same as in

all the US population, thus not representing the general US population. Furthermore, the age ranges differed slightly when comparing the different sites, something that could also influence the inferences. The high participation rate and the 12-month recall period in MrOS may however better reflect the actual fall risk than studies with lower response rates and longer recall period [21, 27–30]. It is also known that retrospective and prospective studies [21, 22, 27–30] may come to different conclusions. The self-reported nature of the falls and fractures should be regarded as a limitation. We must also acknowledge that some significant differences could be the result of multiple comparisons and reflect chance alone. Finally, the inferences drawn in this report should only be regarded as hypothesis generating, as the inferior tests result among the recurrent fallers could also be the result of the recurrent falls.

In conclusion, the present study indicates that inferior physical ability tests in elderly men are associated with recurrent falls. Prospective studies are needed to verify or refute this view.

Key points

- 11.0% of the men had fallen once and 7.7% recurrent times during a 12-month period.
- All physical performance tests discriminated recurrent fallers from both occasional fallers and non-fallers.
- Level of everyday physical performance were in most estimations no different in recurrent fallers, occasional fallers and non-fallers.

Authors' contributions

All authors have contributed to the acquisition of nation-specific data, interpretation of data, critical revision of the manuscript and nation-specific obtaining of funding for the study. J.Å.N. did the statistical analyses. B.R., E.R. and M.K.K. designed the study, wrote the manuscript, analysed the data and were responsible for the international contacts. M.K.K. and J.Å.N. have full access to all data in the study and take responsibility for the integrity of the data and the accuracy of the data analyses.

Conflicts of interests

None of the supporters participated in the design, conduct of the study, collection of data, management, analyses, interpretation of data, preparation of the manuscript, review or approval of the manuscript.

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Determinants of rehabilitation outcome in geriatric patients admitted to skilled nursing facilities after stroke: a Dutch multi-centre cohort study

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