Journal of Physiotherapy xxx (2018) xxx–xxx

Journal of PHYSIOTHERAPY
journal homepage: www.elsevier.com/locate/jphys

Research

Downton Fall Risk Index during hospitalisation is associated with fall-related injuries after discharge: a longitudinal observational study

Mahnaz Mojtaba [a], Hassan Alinaghizadeh [b,c], Elisabeth Rydwik [d,e]

[a] *Jakobsberg's Geriatric Clinic;* [b] *Academic Primary Care Center, Stockholm County Council, Stockholm;* [c] *Department of Medical Sciences, Occupational and Environmental Medicine, Uppsala University, Uppsala;* [d] *FOU nu Research and Development Center for the Elderly, Stockholm County Council, Stockholm;* [e] *Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy, Karolinska Insitutet, Huddinge, Sweden*

KEY WORDS

Elderly
Previous falls
Unsafe gait
Medication
Gender

ABSTRACT

Questions: Among older people who are hospitalised, what is the predictive validity of the Downton Fall Risk Index (DFRI) in relation to fall-related injury after discharge? What is the predictive validity of the DFRI among males and females in this setting? **Design**: Prospective, longitudinal, observational study. **Participants**: All hospital admissions during 2012 at three geriatric clinics in the Stockholm County Council were monitored. Patients aged > 65 years who did not die during the admission and who lived in the Stockholm County Council region were included. **Outcome measures**: The DFRI consists of five modules: previous falls, medication, sensory deficits, mental state, and gait. Three or more points indicate an increased fall risk. Data on DFRI, health status and medications were collected prior to discharge. Data regarding fall-related injuries were collected up to 6 months after discharge. Poisson multivariate regression analyses were conducted to evaluate the association between DFRI and fall-related injuries. **Results**: In total, 6650 patients were analysed. The cut-off ≥ 3 points in the DFRI was significantly associated with fall-related injury when confounding variables were controlled for (IRR 1.94, 95% CI 1.60 to 2.38). Among individual modules, only previous falls (IRR 2.58, 95% CI 2.22 to 3.01) and unsafe gait (IRR 1.79, 95% CI 1.53 to 2.09) were associated with fall-related injuries. Stratified analyses showed a higher risk ratio for men compared to women regarding the DFRI, but the test for an interaction effect was not significant. **Conclusion**: The risk of post-discharge fall-related injury is increased among older hospitalised people with an increased fall risk, according to the DFRI, especially those who had previous falls or unsafe gait. Although the DFRI tool is predictive, previous falls and gait are the measures that are most worthy of focus. **[Mojtaba M, Alinaghizadeh H, Rydwik E (2018) Downton Fall Risk Index during hospitalisation is associated with fall-related injuries after discharge: a longitudinal observational study. *Journal of Physiotherapy* XX: XX–XX]**

Introduction

Older people who are discharged from hospital are at risk of falling. Two studies have shown that 13 to 15% fall within 4 weeks of discharge.[1,2] The risk of a fall after discharge is associated with impairment in activities of daily living, decreased mobility, use of assistive devices, and pre-admission falls.[1,2] Falling once or more during hospitalisation is also associated with increased likelihood of falls after discharge.[3]

Risk factors for fall-related injuries (eg, fractures) are similar to risk factors for falls.[4,5] However, additional risk factors are important in regard to fall-related injuries: low bone mineral density, reaction time, amount of soft tissue padding, previous fractures, the characteristics of the fall (such as falling backwards or sideways), and the energy of the fall.[6] Women have a higher risk of falls than men, and this has been shown to be related to higher gait variability during dual-task activities.[7] They are also more likely to be multiple fallers than men.[8] Risk factors for falls also differ between men and women. For example, incontinence and frailty are risk factors for women, while older age, depression and standing balance are risk factors for men.[9]

Fall prevention actions during hospitalisation might include the use of a fall screening instrument and frequent fall-risk meetings with an interdisciplinary approach.[10] Several fall screening instruments are available.[11] The Downton Fall Risk Index (DFRI) is a validated screening instrument used in a Swedish quality register and is recommended to be used in hospitals, geriatric clinics, care of the elderly, and primary care in Sweden. Several studies have shown that the DFRI can predict falls in residential care,[12] among community-dwellers,[13] and in hospitals.[14] However, it is believed that no studies have evaluated the DFRI in relation to clinically relevant outcomes such as fall-related injuries after hospital discharge. The DFRI has been shown to have higher sensitivity than other instruments,[11] although several studies have also shown low specificity.[11–14] In addition, results from several studies have indicated that the nursing staff's clinical assessment might be as accurate as existing screening tools.[15,16] Since the existing literature shows diverse results and no studies have

https://doi.org/10.1016/j.jphys.2018.05.005

evaluated the DFRI in a hospital setting related to fall-related injuries after discharge or investigated differences between men and women, it requires further evaluation. Thus, the primary aim of this study was to evaluate the predictive validity of DFRI in relation to post-discharge fall-related injury and the secondary aim was to investigate this separately in men and women.

Therefore, the research questions for this prospective, longitudinal, observational study were:

1. Among older people who are hospitalised, what is the predictive validity of the DFRI in relation to fall-related injury after discharge?
2. What is the predictive validity of the DFRI among males and females in this setting?

Method

Design

This was a multi-centre, prospective, longitudinal, observational study conducted in Stockholm County, Sweden. All hospital admissions in 2012 were monitored at three geriatric clinics in Stockholm County Council. If a participant had more than one hospital admission during the data collection period, the last admission was used in the analysis. Participants were followed for 6 months after discharge from hospital to observe for fall-related injury.

Participants

All admitted patients were screened for eligibility. To be eligible for inclusion, patients were required to be aged $\geq$ 65 years.

Data collection

Data were retrieved from two different data sources and then merged into one dataset for analyses. Baseline characteristics collected during each participant's last admission to the geriatric clinics during 2012 were retrieved from the medical records. Follow-up data on fall-related injuries (such as fractures, contusions and fall accidents) were retrieved from the Stockholm County Council Health Care Consumption database within 6 months after discharge from the geriatric clinic. All healthcare providers within the Stockholm County Council – including both hospitals and outpatient clinics (primary care) – were obliged to report the data digitally. The Stockholm County Council Health Care Consumption database covers 99% of all care in Stockholm. The first clinically relevant diagnosis of a fall-related injury that was found was recorded as an event. All observations with no event followed were censored at 6 months. Data regarding falls could not be retrieved from this data source, so data on non-injurious falls were unobtainable.

Dependent variable

The dependent variable was fall-related injury. The International Classification of Diseases (ICD)-10 codes (S, T and W) based on the World Health Organization's International Classification of Diseases were used to extract information about diagnoses related to fall-related injuries from the Stockholm County Council Health Care Consumption database. Specific information about the ICD codes used is presented in Appendix 1 (see eAddenda).

A total of 1146 participants had a fall-related injury. Among these participants, 117 sustained a fracture, 37 sustained a contusion, 145 had a fall accident and 847 had some combination of the three; the most common combination was fracture and fall accident (n = 630).

Independent variable

The DFRI was used to assess risk of falls.[12,13] Fall risk was assessed at admission by the responsible nurse and registered in the medical records. The instrument consists of five modules: previous falls, medication, sensory deficits, mental state, and gait. This results in 11 different risk factors, which are summarised into a score between 0 and 11. Scores $\geq$ 3 points indicate an increased fall risk.[12,13]

Potentially confounding variables

The following information was extracted from the medical records from each participant's last hospital stay in 2012. Age, gender, and number of diagnoses were recorded. The number and type of medications were also extracted from the medication record.

Mini Nutritional Assessment was used to measure nutritional status.[17] The instrument is based on scores between 0 and 14 points, where 0 to 7 points is regarded as malnutrition, 8 to 11 points is regarded as at risk of malnutrition, and 12 to 14 points is regarded as normal nutritional status. In the regression analyses, this variable was dichotomised as 1 for malnutrition or 0 for at risk of malnutrition or normal nutritional status. Body mass index was used to classify underweight ($<$ 18.5), overweight (25.0 to 29.9) and obesity ($\geq$ 30.0). Information about body mass index was extracted from the Mini Nutritional Assessment. The variable was dichotomised and a cut-off for underweight $<$ 23 kg/m^2 was used.[18]

Haemoglobin was used to classify anaemia. This variable was dichotomised using a cut-off for anaemia set at $<$ 115 g/l.[19] Data on blood pressure were dichotomised according Klein et al,[19] where a low blood pressure can increase the risk of falling. The cut-off for low blood pressure was set to $<$ 120 mmHg for systolic and $<$ 80 mmHg for diastolic.[20]

C-reactive protein was used to estimate inflammatory levels. The variable was dichotomised and a level of $>$ 10 g/l was used as a cut-off indicating a high inflammatory level.[21]

Data analysis

Demographic and background factors at baseline were presented as mean, standard deviation and frequencies. Between-group comparison was carried out by *t*-test for continuous data and Chi-squared test for nominal data, where statistical assumptions were not violated. When normality assumptions for continuous data were not met, the Mann-Whitney test was used to compare differences between groups. For between-group analysis in relation to the DFRI, the Kruskal-Wallis equality-of-populations rank test was used.

Poisson regression was used to assess how strongly the outcome of fall-related injury was associated with the DFRI and its individual modules. The analysis treated fall-related injury dichotomously and therefore did not allow for the possibility of more than one injury per participant. Due to multicollinearity, all of the DFRI modules were used as exposures and a separate model was applied for the full DFRI (dichotomised based on the cut-off $\geq$ 3 points) as well as each module. Apart from the potential confounding variables described above, an interaction term with gender and the DFRI module was added in each model. For those models where a significant association was found, bootstrapping with 1000 replications and Jackknife estimation were applied.[22]

Complementary analyses were also conducted among specific medications that have been shown to be associated with an increased risk of falls and fall-related injuries.[23] The following medications were chosen for further analyses: diuretics, antihypertensives (not diuretics), antiparkinsonian drugs, neuroleptics, antidepressants, tramadol, Propavan, benzodiazepine (long-lasting), and Nozinan.

All statistical analyses were performed using SAS software[a]. A 5% significance level was chosen to reject the null hypothesis.

Please cite this article in press as: Mojtaba M, et al. Downton Fall Risk Index during hospitalisation is associated with fall-related injuries after discharge: a longitudinal observational study. *J Physiother.* (2018), https://doi.org/10.1016/j.jphys.2018.05.005

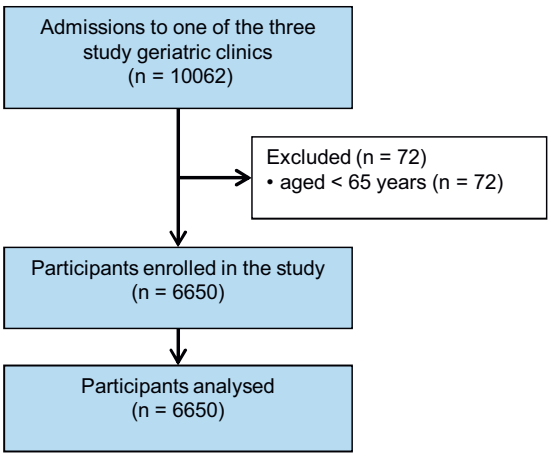

Figure 1. Flow of participants through the study.

Results

Flow of participants through the study

During the data collection period, 10 062 admissions occurred at three participating geriatric clinics in Stockholm County Council. Several patients had more than one admission. Therefore, the 10 062 hospital admissions resulted in 6650 participants who were included and analysed in the study. See Figure 1.

Characteristics of the study participants

A description of the baseline characteristics of all participants are shown in Table 1. The characteristics of the subgroups of participants who did and did not sustain a fall-related injury after discharge are also presented in Table 1. Of the 6650 subjects, 1146 (17%) sustained a fall-related injury during the 6-month follow-up. The mean age in both groups with and without fall-related injury was 84 years. Women were significantly more likely to sustain a fall-related injury than men. There were significant differences between those with and without fall-related injury regarding previous falls, gait and fall risk according to DFRI (≥ 3 points), as presented in Table 2. Among those who sustained a fall-related injury, 83% had a high fall risk according to DFRI. Of those who did not sustain a fall-related injury, 22% were correctly classified as having no fall risk (Table 2). The corresponding proportion for men and women was similar. Of those who sustained a fall-related injury, mean days to sustain the injury were 59 days (SD 53, 95% CI 56 to 62) (Figure 2).

The regression analyses showed a significant association between the cut-off ≥ 3 points according to the DFRI and fall-related injury when confounding variables were controlled for. When analysing the individual modules of the DFRI, only previous falls and unsafe gait were associated with fall-related injuries (Table 3).

Since there was no significant association between the medication module and fall-related injury, despite previously shown associations, complementary analyses were conducted. As seen in Table 3, there was a low but significant association between not using diuretics and fall-related injuries, when controlling for confounding variables. There was no significant interaction between gender and fall risk according to DFRI (≥ 3 points). There was also no significant interaction between gender and either of the two significant DFRI modules in the final models. However, due to the significant main effect (DFRI module and gender), these differences are visualised in Figure 3. On the other hand, the association between not using diuretics and fall-related injury was only significant among women (IRR 1.40, 95% CI 1.16 to 1.70).

Table 1
Demographic and clinical characteristics of all participants at baseline, also categorised according to no fall injury and fall injury within 6 months after discharge.

Risk factors	All (n = 6650)	No fall injury (n = 5504)	Fall injury (n = 1146)
Women, n (%)[a]	4277 (64)	3478 (63)	799 (70)
Men, n (%)	2373 (36)	2026 (37)	347 (30)
Age, mean (SD)	84 (7)	84 (7)	84 (8)
Diagnoses *(n)*, mean (SD)	4 (2)	4 (2)	4 (2)
Medications *(n)*, mean (SD)	4 (2)	4 (2)	4 (2)
missing n (%)	275 (4)	232 (4)	43 (4)
Mini Nutritional Assessment *(points)*, n (%)			
0 to 7	1833 (28)	1544 (28)	294 (26)
8 to 11	3417 (51)	2811 (51)	606 (53)
12 to 14	1249 (19)	1020 (19)	229 (20)
missing	146 (2)	129 (2)	17 (1)
Body Mass Index, n (%)[b]			
< 23	3527 (53)	2906 (53)	621 (54)
≥ 23	2843 (43)	2352 (43)	491 (43)
missing	280 (4)	246 (4)	34 (3)
Haemoglobin *(g/l)*, n (%)[a]			
≤ 115	2190 (33)	1761 (32)	429 (37)
> 115	3406 (51)	2842 (52)	564 (49)
missing	1054 (16)	901 (16)	153 (13)
Systolic blood pressure *(mmHg)*, n (%)[c]			
≤ 120	1689 (25)	1432 (26)	257 (22)
> 120	4703 (71)	3847 (70)	856 (75)
missing	258 (4)	225 (4)	33 (3)
Diastolic blood pressure *(mmHg)*, n (%)			
≤ 80	4731 (71)	3908 (71)	823 (72)
> 80	1660 (25)	1370 (25)	290 (25)
missing	259 (4)	226 (4)	33 (3)
C-reactive protein *(g/l)*, n (%)			
≤ 10	3867 (58)	698 (61)	3169 (58)
> 10	1545 (23)	256 (22)	1289 (23)
missing	1238 (19)	192 (17)	1046 (19)

[a] $p < 0.001$, indicating a significant difference between women and men in the prevalence of fall injury.
[b] Determined according to the Mini Nutritional Assessment.
[c] $p < 0.05$, indicating a significant difference between no fall injury and fall injury.

Discussion

This study showed a significant association between fall-related injuries and a high fall risk according to the DFRI. Similarly, a significant association was shown between fall-related injuries and either the previous falls or unsafe gait modules. These results are in line with a recently published study that showed that DFRI independently predicted fall-related injuries[24] however, the populations partly differed. The current results are also in line with a study by Vassallo et al,[25] which showed that previous falls and unsafe gait are associated with fall-related injuries. Similar to that study,[25] clinical characteristics between subjects with or without fall-related injuries did not differ in most of the variables in the current study (Table 1). These results suggested that identifying patients at risk of injury is difficult and multi-faceted. This difficulty is emphasised by the paradox shown in a study by Aranda-Gallardo et al,[26] in which there was an increased odds ratio for fall-related injury among those classified as low risk according to the DFRI. This highlights the problematic features of relying too much on screening, where patients screened with a low risk are not further investigated, and therefore no preventive actions are taken.[26]

The current results showed that 17% of the sample sustained an injurious fall within 6 months of discharge. This is somewhat different compared to another study showing that 11% sustained an injurious fall after discharge.[3] The difference might be explained by a difference in length of follow-up and whether the injury required hospital care or not.

To our knowledge, this is the first study to conduct stratified analyses by gender regarding fall risk screening. The current results indicated a higher incidence risk ratio for fall-related injuries in men according to the DFRI; however, the difference was not significant (shown by the non-significant interaction effect on

Please cite this article in press as: Mojtaba M, et al. Downton Fall Risk Index during hospitalisation is associated with fall-related injuries after discharge: a longitudinal observational study. *J Physiother.* (2018), https://doi.org/10.1016/j.jphys.2018.05.005

Table 2
Results of screening with the Downton Fall Risk Index and its individual modules in relation to fall injuries (n = 6650).

Risk factors	No fall injury (n = 5504)	Fall injury (n = 1146)
Previous falls, n (%)[a]		
no	2571 (47)	307 (27)
yes	2785 (51)	818 (71)
missing	148 (2)	21 (2)
Medication, n (%)		
none	957 (17)	207 (18)
tranquilisers/sedatives	2143 (39)	448 (39)
diuretics	1670 (30)	349 (30)
antihypertensive (other than diuretics)	463 (8)	103 (9)
antiparkinsonian drugs	108 (2)	17 (1)
antidepressants	14 (< 1)	2 (< 1)
missing	149 (3)	20 (2)
Sensory deficits, n (%)		
none	1449 (26)	298 (26)
visual impairment	2675 (49)	561 (49)
hearing impairment	1122 (20)	250 (22)
limb impairment	111 (2)	16 (1)
missing	147 (3)	21 (2)
Mental state, n (%)		
orientated	4111 (75)	838 (73)
confused (cognitively impaired)	1250 (23)	287 (25)
missing	143 (3)	21 (2)
Gait, n (%)[a]		
normal (safe with or without walking aids)	1997 (36)	293 (26)
unsafe (with or without walking aids)	3364 (61)	833 (73)
missing	143 (3)	20 (2)
DFRI fall risk *(1 to 11)*, n (%)[a]		
1 to 2 (no fall risk)	1201 (22)	172 (15)
3 to 11 (fall risk)	4144 (75)	950 (83)
missing	159 (3)	24 (2)

[a] $p < 0.001$, indicating a significant difference on Chi-squared test.

gender). However, data regarding sensitivity and specificity were similar in men and women (data not shown), so this problem remains. A recent study investigated differences in risk factors for falls between women and men, and found that some risk factors were the same, while others (such as incontinence and frailty) were significant only in women.[9] Another study showed that men who were regarded as frail had a higher risk for falls compared to women who were regarded as frail.[27]

Somewhat opposite to other studies, this study showed no association with polypharmacy,[28] or between antidepressants and psychotropic drugs with fall-related injury.[23,29] However, this might partly be explained by different outcomes (falls instead of fall-related injuries,[23] and hip fractures alone).[29] Using hypertensive drugs was not related to fall-related injuries – neither in the multivariate analyses nor in the stratified analysis – which is in line with other studies.[30,31] Surprisingly, this study showed that women who did not use diuretics had an increased risk of fall-related injuries. This is both in line with and somewhat opposite to other studies. Thorell et al[29] showed no association between diuretics and hypertensives with hip fracture. Another study showed a higher prevalence of diuretics among non-fallers compared to fallers, as well as among non-injured fallers compared to injured fallers.[25] A Cochrane review showed that thiazide diuretics reduced the risk of hip fracture;[31] however, the conclusion was based solely on observational studies solely. One clinical explanation could be that women suffering from dizziness or orthostatic hypotension might have discontinued with the drugs. Again, different outcomes and stratification might explain the different results, but this also highlights the complexity of the area being studied.

Mental state was not associated with fall-related injuries, which is not in line with a previous review.[32] However, the data on cognition in this study relate to the mental state module in DFRI, which makes comparison difficult. Unfortunately, data on cognition measured with the Mini Mental State Examination were only available for a small portion of the sample. Therefore, no supplementary analyses were conducted.

The DFRI showed high sensitivity but low specificity in relation to fall-related injuries (Table 2). This is partly in line with previous studies that showed similar results, but in relation to falls.[8–10] Olsson Möller et al[13] investigated other cut-offs in frail community-dwelling older adults in relation to falls, and concluded that the predictive validity was low regardless of cut-off. Lower cut-offs showed higher sensitivity and lower specificity and higher cut-offs the opposite.[13]

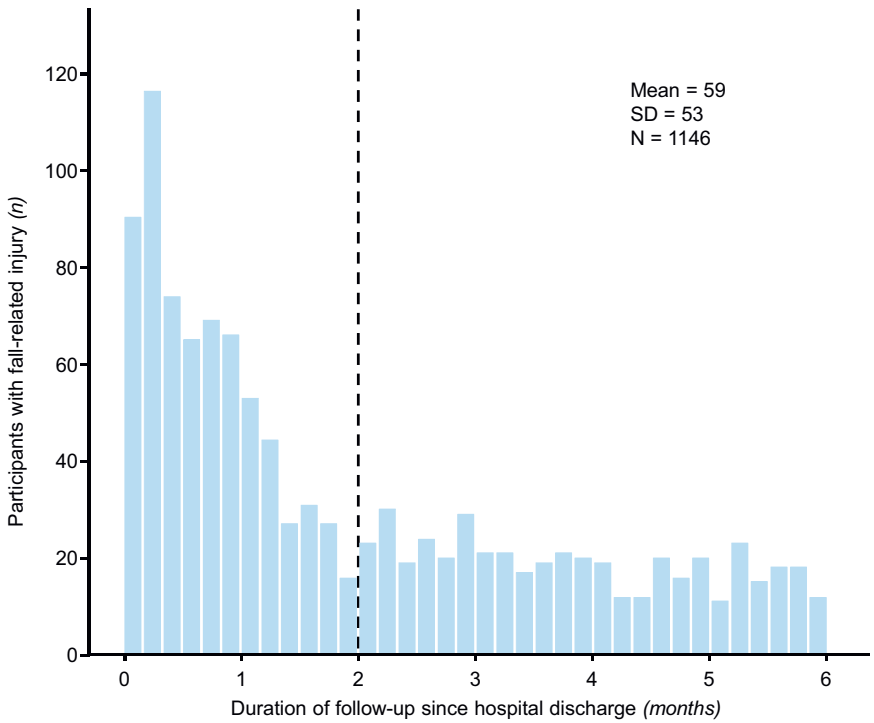

Figure 2. Distribution of observation with fall-related injuries at 6-month follow-up. The dashed line shows mean time to fall-related injury (59 days).

Please cite this article in press as: Mojtaba M, et al. Downton Fall Risk Index during hospitalisation is associated with fall-related injuries after discharge: a longitudinal observational study. *J Physiother.* (2018), https://doi.org/10.1016/j.jphys.2018.05.005

Table 3
Observed incident rate ratios (95% CI) for fall injury depending on risk factors at the 6-month follow-up.

Explanatory variables	Observed IRR (Normal-based 95% CI)[a]		
	Crude model	Model A	Model B
Downton ≥ 3	1.57 (1.32 to 1.86)	1.59 (1.34 to 1.88)	1.94 (1.58 to 2.37)
Previous falls	2.36 (2.07 to 2.70)	2.37 (2.07 to 2.72)	2.53 (2.15 to 2.96)
Gait	1.65 (1.44 to 1.89)	1.67 (1.44 to 1.93)	1.78 (1.51 to 2.11)
Not using diuretics	1.28 (1.12 to 1.46)	1.28 (1.12 to 1.46)	1.34 (1.13 to 1.58)
Not using antihypertensives	1.13 (1.00 to 1.27)	1.13 (1.00 to 1.28)	1.07 (0.92 to 1.24)

Downton < 3, no previous falls, safe gait, using diuretics and using antihypertensive are reference categories.
Model A was adjusted for age and gender.
Model B was adjusted for age, gender, gender*explanatory variable, number of diagnoses, number of medicines, Mini Nutritional Assessment, body mass index, haemoglobin, systolic and diastolic blood pressure, and C-reactive protein.
[a] Bootstrap with 1000 replications and Jackknife estimation.

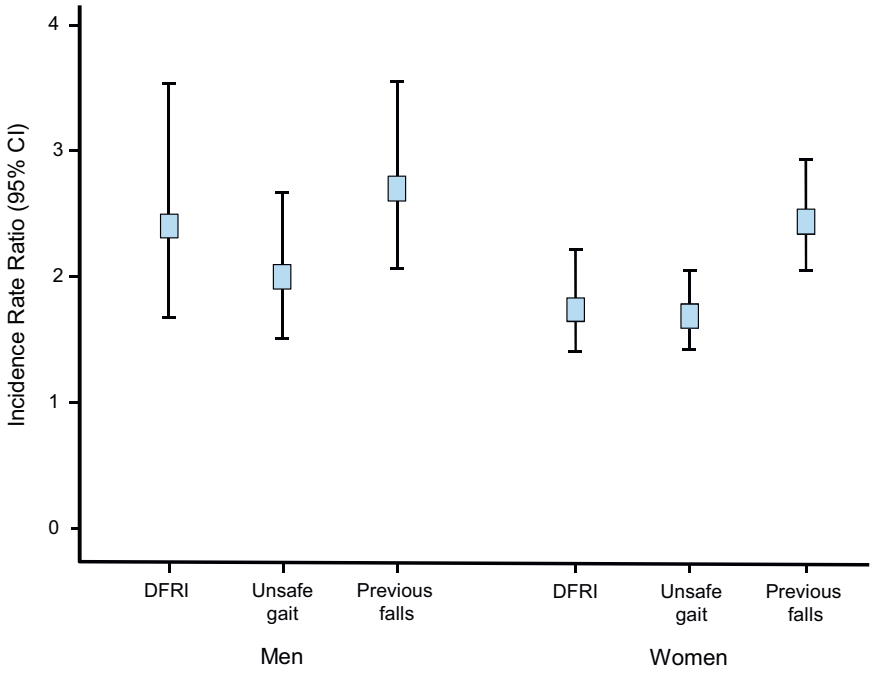

Figure 3. Stratified incidence rate ratio by sex for fall injury according Downton Fall Risk Index when controlling for confounding variables.

The results in this and previous studies suggest that screening tools should only be used as indicators of risks and should be followed by further evaluation of the individual's risk profile for falls and fall-related injuries.[33] It seems as though previous falls, unsafe gait and maybe also previous fractures[6] are important risk factors and warrant further individualised evaluations in clinical settings. The National Institute for Health and Care Excellence (NICE) guidelines suggest a thorough examination. This should be followed by a multidisciplinary, person-centred approach regarding fall prevention, with a specific focus on unsafe gait.[16,33] There is substantial evidence that exercise can prevent risk factors of falls such as unsafe gait.[33]

This study had some limitations. There were no data regarding causes for admission at baseline. Since this is a database study, there was no information about fall characteristics, presence of osteoporosis, current health status, and other factors associated with the fall-related injury. In addition, there was only information about those who sought care for the fall-related injury, and the number of falls not requiring care was unknown. However, strengths of the study included the large sample size and the 99% coverage of all care in Stockholm by the Stockholm County Council Health Care Consumption database.

In conclusion, this study provides new insights into the DFRI and fall-related injuries. No previous studies have evaluated the individual modules of the DFRI. This study showed an increased risk of fall-related injuries if the patient had a risk for falls according to the DFRI, especially if they had previous falls and unsafe gait. Although there was similarity in results with many previous studies, these results could be further validated in future studies. The results suggest that identifying patients at risk of injury is problematic and multi-faceted, and highlight the complexity of the area and the need for a broad, individualised assessment with an inter-disciplinary approach. However, a fall-risk assessment should be conducted before discharge, focusing on previous falls and gait instability. In order to decrease the risk of fall-related injuries after discharge, the results of the assessments should then influence the level of care provided.

What was already known on this topic: After discharge from hospital, older people are at risk of falling. Several risk factors for these falls and fall-related injuries have been identified. Some of these risk factors differ between men and women. The Downton Fall Risk Index incorporates some of these risk factors to predict falls in the community, residential care and hospitals.
What this study adds: Among hospitalised older people, the Downton Fall Risk Index predicts fall-related injury after discharge. Previous falls and gait were the items on the Downton Fall Risk Index that were most predictive.

Please cite this article in press as: Mojtaba M, et al. Downton Fall Risk Index during hospitalisation is associated with fall-related injuries after discharge: a longitudinal observational study. *J Physiother.* (2018), https://doi.org/10.1016/j.jphys.2018.05.005

Footnotes: [a] SAS 9.4, SAS Institute Inc, Cary, NC, USA.

eAddenda: Appendix 1 can be found online at https://doi.org/10.1016/j.jphys.2018.05.005

Ethics approval: Approved by the Regional Ethical Review Board in Stockholm, Sweden (DNR: 2013/1620-31/2). Since data in this study were only based on database information, Ethics Approval permitted informed consents not to be collected.

Competing interest: The authors declare no conflict of interest.

Source of support: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements: Nil.

Provenance: Not invited. Peer reviewed.

Correspondence: Elisabeth Rydwik, Department of Neurobiology, Care Sciences and Society, Division of Physiotherapy, Karolinska Insitutet, Huddinge, Sweden. Email: elisabeth.rydwik@ki.se

References

1. Mahoney JE, Palta M, Johnson J, Jalaluddin M, Gray S, Park S, et al. Temporal association between hospitalization and rate of falls after discharge. *Arch Intern Med.* 2000;160:2788–2795.
2. Mahoney J, Sager M, Dunham NC, Johnson J. Risk of falls after hospital discharge. *J Am Geriatr Soc.* 1994;42:269–274.
3. Davenport RD, Vaidean GD, Jones CB, Chandler AM, Kessler LA, Mion LC, et al. Falls following discharge after an in-hospital fall. *BMC Geriatr.* 2009;9:53.
4. Oliver D, Daly F, Martin FC, McMurdo MET. Risk factors and risk assessment tools for falls in hospital in-patients: A systematic review. *Age Ageing.* 2004;33:122–130.
5. Ensrud KE, Ewing SK, Taylor BC, Fibk HA, Stone KL, Cauley JA, et al. Frailty and risk of falls, fracture, and mortality in older women: the study of osteoporotic fractures. Study of Osteoporotic Fractures Research Group. *J Gerontol A Biol Sci Med Sci.* 2007;62:744–751.
6. Ensrud K. Epidemiology of fracture risk with advancing age. *J Gerontol A Biol Sci Med Sci.* 2013;68:1236–1242.
7. Johansson J, Nordström A, Nordström P. Greater fall risk in elderly women than in men is associated with increased gait variability during multitasking. *J Am Med Dir Assoc.* 2016;17(6):535–540.
8. Morris M, Osborne D, Hill K, Kendig H, Lundgren-Lindquist B, Browning C, et al. Predisposing factors for occasional and multiple falls in older Australians who live at home. *Aust J Physiother.* 2004;50:153–159.
9. Gale CR, Cooper C, Sayer AA. Prevalence and risk factors for falls in older men and women: The English Longitudinal Study of Ageing. *Age Ageing.* 2016;45:789–794.
10. Vassallo M, Vignaraja R, Sharma JC, Hallam H, Binns K, Briggs R, et al. The effect of changing practice on fall prevention in a rehabilitative hospital. *J Am Geriatr Soc.* 2004;52:335–339.
11. Vassallo M, Stockdale R, Sharma JC, Briggs R, Allen S. A comparative study of the use of four fall risk assessment tools on acute medical wards. *J Am Geriatr Soc.* 2005;53:1034–1038.
12. Rosendahl E, Lundin-Olsson L, Kallin K, Jensen J, Gustafson Y, Nyberg L. Prediction of falls among older people in residential care facilities by the Downton index. *Aging Clin Exp Res.* 2003;15:142–147.
13. Olsson Möller U, Kristensson J, Midlöv P, Ekdahl C, Jakobsson U. Predictive validity and cut-off scores in four diagnostic tests for falls – A study in frail older people at home. *Phys Occup Ther Geriatr.* 2012;30:189–201.
14. Haines TP, Hill K, Walsh W, Osbome R. Design-related bias in hospital fall risk screening tool predictive accuracy evaluations: Systematic review and meta-analysis. *J Gerontol A Biol Sci Med Sci.* 2007;6:664–672.
15. Meyer G, Köpke S, Haastert B, Mühlhauser I. Comparison of a fall risk assessment tool with nurses' judgement alone: a cluster-randomised controlled trial. *Age Ageing.* 2009;38:417–423.
16. National Institute for Health and Care Excellence, NICE Falls in older people, 2015. https://www.nice.org.uk/guidance/qs86 [accessed 16/05/2016].
17. Vallas B, Villars H, Abellan G, Soto ME. Overview of the MNA – Its history and challenges. *J Nutr Health Aging.* 2006;10:456–463.
18. Al Snih S, Ottenbacher K, Markides K, Kuo Y-F, Eschbach K, Goodwin JS. The effect of obesity on disability vs. mortality in older Americans. *Arch Intern Med.* 2007;167:774–780.
19. Nilsson-Ehle H, Jagenburg R, Landahl S, Svanborg A. Blood haemoglobin declines in the elderly: implications for reference intervals from age 70 to 88. *Eur J Haematol.* 2000;65:297–305.
20. Klein D, Nagel G, Kleiner Ulmer H, Rehberger B, Concin H, Rapp K. Blood pressure and falls in community-dwelling people aged 60 years and older in the VHM&PP cohort. *BMC Geriatr.* 2013;13:50.
21. Heeschen C, Hamm C, Bruemmer J, Simoons ML, CAPTURE Investigators. Predictive value of C-reactive protein and troponin T in patients with unsafe angina: a comparative analysis. *J Am Coll Cardiol.* 2000;35:1535–1542.
22. Mooney CZ, Duval RD. *Bootstrapping: A Nonparametric Approach to Statistical Inference.* Newbury Park, CA: Sage; 1993.
23. Titler MG, Shever LL, Kanak MF, Picone DM, Qin R. Factors associated with falls during hospitalization in an older adult population. *Res Theory Nurs Pract.* 2011;25:127–152.
24. Nilsson M, Eriksson J, Larsson B, Odén A, Johansson H, Lorentzon M. Fall risk assessment predicts fall-related injury, hip fracture, and head injury in older adults. *J Am Geriatr Soc.* 2016;64:2242–2250.
25. Vassallo M, Vignaraja R, Sharma JC, Briggs R, Allen S. The relationship of falls to injury among hospital in-patients. *Int J Clin Pract.* 2005;59:17–20.
26. Aranda-Gallardo M, Morales-Asencio JM, Canca-Sanchez JC, Toribio-Montero JC. Circumstances and causes of falls by patients at a Spanish acute care hospital. *J Eval Clin Pract.* 2014;20:631–637.
27. Kojima G. Frailty as a predictor of future falls among community-dwelling older people: A systematic review and meta-analysis. *J Am Med Dir Assoc.* 2015;16:1027–1033.
28. Laflamme L, Monárrez-Espino J, Johnell K, Elling B, Möller J. Type, number or both? A population-based matched case-control study on the risk of fall-related injuries among older people and number of medications beyond fall-inducing drugs. *PLoS One.* 2015;10:e0123390.
29. Thorell K, Ranstad K, Midlöv P, Borgquist L, Halling A. Is use of fall risk-increasing drugs in an elderly population associated with an increased risk of hip fracture, after adjustment for multimorbidity level: a cohort study. *BMC Geriatr.* 2014;14:131.
30. Zia A, Kamaruzzaman SB, Myint PK, Tan MP. The association of antihypertensives with postural blood pressure and falls among seniors residing in the community: a case-control study. *Eur J Clin Invest.* 2015;45:1069–1076.
31. Aung K, Htay T. Thiazide diuretics and the risk of hip fracture. *Cochrane Database Syst Rev.* 2011;10:CD005185.
32. Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in fall risk among older adults: a systematic review and meta-analysis. *Age Ageing.* 2012;41:299–308.
33. Sherrington C, Tiedemann A. Physiotherapy in the prevention of falls in older people. *J Physiother.* 2015;61:54–60.

Please cite this article in press as: Mojtaba M, et al. Downton Fall Risk Index during hospitalisation is associated with fall-related injuries after discharge: a longitudinal observational study. *J Physiother.* (2018), https://doi.org/10.1016/j.jphys.2018.05.005