Management of fear of falling after hip fracture

Scheffers-Barnhoorn, M.N.

Chapter 6

Course of fear of falling after hip fracture: findings from a 12-month inception cohort.

Submitted as: Scheffers-Barnhoorn MN, Haaksma ML,
Achterberg WP, Niggebrugge AHP, van der Sijp MPL, van Haastregt JCM, van Eijk M.

ABSTRACT

Objectives

To examine the course of fear of falling (FoF) up to one year after hip fracture, including the effect of pre-fracture FoF on the course.

Design

Observational cohort study with 12-month follow-up.

Setting

Haaglanden Medical Centre, the Netherlands.

Participants

444 community-dwelling adults aged 70 years and older, admitted to hospital with a hip fracture.

Main outcome measure

Short Falls Efficacy Scale International (FES-I), with a cut-off score ≥ 11 to define elevated FoF levels.

Results

Six weeks after hip fracture the study population-based mean FES-I was located around the cut-off value of 11, and levels decreased only marginally over time. One year after fracture almost one-third of the population had FoF (FES-I ≥ 11). Although the group with pre-fracture FoF (42.6%) had slightly elevated FES-I levels during the entire follow-up, the effect was not statistically significant. Patients with persistent FoF at 6 and 12 weeks after fracture (26.8%) had the highest FES-I levels, with a mean well above the cut-off value during the entire follow-up. For the majority of patients in this group FoF is still present one year after fracture (84.9%).

Conclusions

FoF as defined by a FES-I score ≥ 11 is common within the first year after hip fracture. Patients with persistent FoF at 12 weeks have the highest FES-I levels in the first year after fracture, and for most of these patients the FoF remains. For timely identification of patients who may benefit from intervention, we recommend structural assessment of FoF, which includes screening for (pre-fracture) FoF immediately after fracture, and subsequently at onset of rehabilitation, and 12 weeks after fracture.

Key words

Fear of falling, hip fracture, clinical course, prospective cohort study

INTRODUCTION

Hip fracture, being one of the most serious fall-related injuries and representing the second most common fragility fracture in older adults, has a significant impact on the health care system [1,2]. Despite extensive rehabilitation, a considerable number of patients experience permanent morbidity and disability, resulting in substantial costs in both (post-)acute settings and long-term care [3-6]. Moreover, the expected rise in absolute numbers – up to 4 million in 2025, and over 6 million in 2050 – will further contribute to the high economic burden and societal impact [7,8]. To date, many prognostic factors have been identified [9-11]. This includes fear of falling (FoF), defined as '*a lasting concern about falling that leads to an individual avoiding activities that he/she remains capable of performing*' [12-15]. Considering that FoF is common following hip fracture and has been found to impede functional recovery after fracture, this may be a meaningful factor to address in order to improve the recovery process [13,14,16,17].

Although various effective treatment programmes are available for community-dwelling older adults, studies evaluating treatment of FoF for patients with hip fracture are scarce, and their findings inconclusive [18-21]. One possible explanation for the inconsistent findings is the timing of the intervention. To date, the interventions have been conducted mainly during inpatient rehabilitation, representing the early stage of recovery. However, associations between FoF and impaired functional recovery were found primarily for the period six weeks after fracture and beyond, not for the early stages after hip fracture (2-4 weeks) [13,14]. This may imply that FoF in the early stages of recovery is not a barrier to functional recovery under all circumstances. Insight into the course of FoF after hip fracture can provide a better understanding of the characteristics of FoF in this population, and help differentiate between patients with limited FoF, and those at risk for *maladaptive* FoF, i.e., those forms of FoF that lead to impairment of physical activities and daily functioning. In turn, this may help identify patients who may benefit from intervention. However, at present little is known about the clinical course of FoF after hip fracture, and the available data on this subject is limited by short follow-up [22].

In light of the above-mentioned knowledge gap, the objective of this study is to examine the course of FoF up to one year after fracture. This includes analysis of FoF trajectories for specific subgroups that could be relevant for clinical practice, such as patients who have experienced FoF prior to the hip fracture. No previous studies have evaluated how pre-fracture FoF relates to FoF after fracture. However, the a*bsence* of pre-fracture FoF has been associated with *successful* short-term functional recovery, which points towards an important role for pre-fracture FoF in the recovery process [12]. Although the mechanism for this effect remains to be determined, we expect that pre-fracture FoF has the potential to affect the course of FoF after fracture, and could therefore affect functional outcome. For this purpose we will explore FoF trajectories based on the presence / absence of FoF prior to fracture. Furthermore, we

will explore whether persistent FoF in the first 12 weeks (short-term) is related to an increased risk for FoF one year after fracture.

METHODS

Study design, setting and patients

This is a longitudinal observational inception cohort study. The study population consists of patients with a hip fracture admitted to the *Haaglanden Medical Center* hospital, the Netherlands, in the period 1 January 2018 to 1 March 2020. All data was assessed as part of routine data collection for this target group [23]. We included all patients aged 70 years or older, who were community-dwelling prior to fracture (i.e., not permanently residing in a nursing home or other residential care setting before admission), and for whom complete data was available for the covariates required for the analyses (see below).

The Medical Research Ethics Committee of the Haaglanden Medical Center, and the hospital's board of directors approved the study protocol of the inception cohort (METC Southwest Holland; protocol number 16-059) [23]. Because of its observational design, informed consent was not required according to the Dutch regulations. This current study has been performed in accordance with the STROBE guidelines [24].

Assessments

Data was collected at four fixed time points. Baseline data was collected during hospital admission. Follow-up assessments were conducted during the out-patient follow-up visits at 6, 12 and 52 weeks after fracture.

Primary outcome measure

Fear of falling was measured with the Short Falls Efficacy Scale International (FES-I), administered during all three follow-up visits. The Short FES-I is a 7-item instrument, scored on a 4-point Likert scale, assessing FoF related to basic physical and social activities. The total score on the Short FES-I ranges from 7 to 28, with higher scores indicating a higher level of FoF. The Short FES-I has proved to be a valid measure to assess FoF in frail older adults, including those with cognitive impairment [25]. The standard FES-I cut-off score of ≥ 11 was used as reference to define elevated levels of FoF [26].

FoF trajectories for specific patient groups

The course of FoF was modelled for specific subgroups, based on factors expected to distinguish between high or low FoF levels. This led to FoF trajectories for specific subgroups.

First, we compared the course of FoF for patients with pre-fracture FoF to those without it. Pre-fracture FoF was assessed in retrospect, related to the period directly before fracture, using a one-item fear of falling question ('*Are you afraid of falling?*') [27]. Pre-fracture FoF was operationalized as follows: 1] no pre-fracture FoF (patients reporting '*not at all*'); and 2] pre-fracture FoF present (patients reporting either '*a little*', '*quite a bit*' or '*very much*').

Secondly, we explored FoF trajectories for groups based on FoF status at 6 *and* 12 weeks. Using the FES-I cut-off score of 11, this led to the following *FoF trend groups*: 1] No FoF (= FES-I < 11 at 6- and 12-week follow-up); 2] Transient FoF (= FES-I ≥ 11 at 6 weeks and FES-I < 11 at 12 weeks); 3] Late-onset FoF (= FES-I < 11 at 6 weeks and ≥ 11 at 12 weeks); 4] Persistent FoF (= FES-I ≥ 11 at 6 and 12 weeks).

Independent variables

Pre-fracture mobility and comorbidity have been associated with FoF after hip fracture and were therefore included as covariates in the statistical models [22,28]. The *Parker Mobility Score* (PMS) was used as a (retrospective) measure of mobility [29], related to the period directly before fracture. This measurement instrument assesses indoor- and outdoor mobility, and the ability to do shopping. Each item is scored as: no difficulty; with walking aid; with assistance; or not at all able. The total score ranges from 0-9, with higher scores indicating better mobility. For the analyses, pre-fracture PMS was dichotomized into PMS < 9 (assistance needed in mobility) and PMS 9 (independent mobility). The *American Society of Anesthesiologists classification* (ASA) [30] was used to measure general health status (indirectly a measure of medical comorbidity; no other data on comorbidity available in current data set). For the analyses, this variable was dichotomized (category I-II, and > II). Age, which has been associated with FoF in older adults, was also included as a covariate [31].

Additional variables

For a background description of the study population several characteristics were determined, including age and sex. Independence in activities in daily living (ADL) was measured using the *Katz Index of Independence in Activities of Daily Living* (Katz-ADL). It was assessed in retrospect, related to the period directly before fracture, to describe pre-fracture level of functioning [32]. Cognitive impairment is common in this population and was determined based on an existing formal diagnosis of dementia, and with the *6-Item Cognitive Impairment Test* (6-CIT) [33,34]. Nutritional problems are frequently reported for this population, and these were measured with the *Mini Nutritional Assessment–Short Form* (MNA-SF) [35].

To provide insight into the extent of functional recovery after fracture, we used a combined outcome measure, which represents the recovery of independence of ADL [6,12]. The combined outcome measure is based on the following variables: 1] mortality; 2] (in)dependent living

situation; and 3] recovery of ADL function to pre-fracture level, measured with KATZ-ADL. *Successful* recovery was operationalized as: no mortality (all causes) + living independently in a private residence (including a residential home setting, and as needed with home care) + recovery to pre-fracture ADL function (current KATZ ADL ≤ pre-fracture ADL). Recovery was considered *unsuccessful* when not all criteria were met. Rates of successful recovery are presented for the 6-, 12-, and 52-week follow-up for the four *FoF trend groups*.

Statistical analysis

Descriptive analyses were used to summarize characteristics of the study population. To examine the course of FoF up to one year after fracture, we used linear mixed models (LMM). The unconditional growth model - illustrating the course of FoF for the study population as a whole – modelled FES-I as linear function of time; with *age, pre-fracture PMS* and *ASA classification* as covariates (all centred to the mean); in addition to a random intercept. Time was operationalized as weeks since hip fracture.

We examined the effect of pre-fracture FoF on the course of FoF after fracture, in linear mixed model 1 (LMM1). LMM1 was an extension of our unconditional growth model, which additionally included pre-fracture FoF as a predictor of the intercept and the slope. In the second linear mixed model (LMM2) we explored the course for the four FoF trend groups. LMM2 included the same covariates as LMM1, with in addition the FoF trend group variable as a predictor of the intercept and the slope. In contrast to the unconditional model and LMM1, the FES-I in LMM2 was modelled from 12 weeks post hip fracture onward, as this model included the independent variable 'FoF trend groups', which was based on the observed FES-I at 6 and 12 weeks.

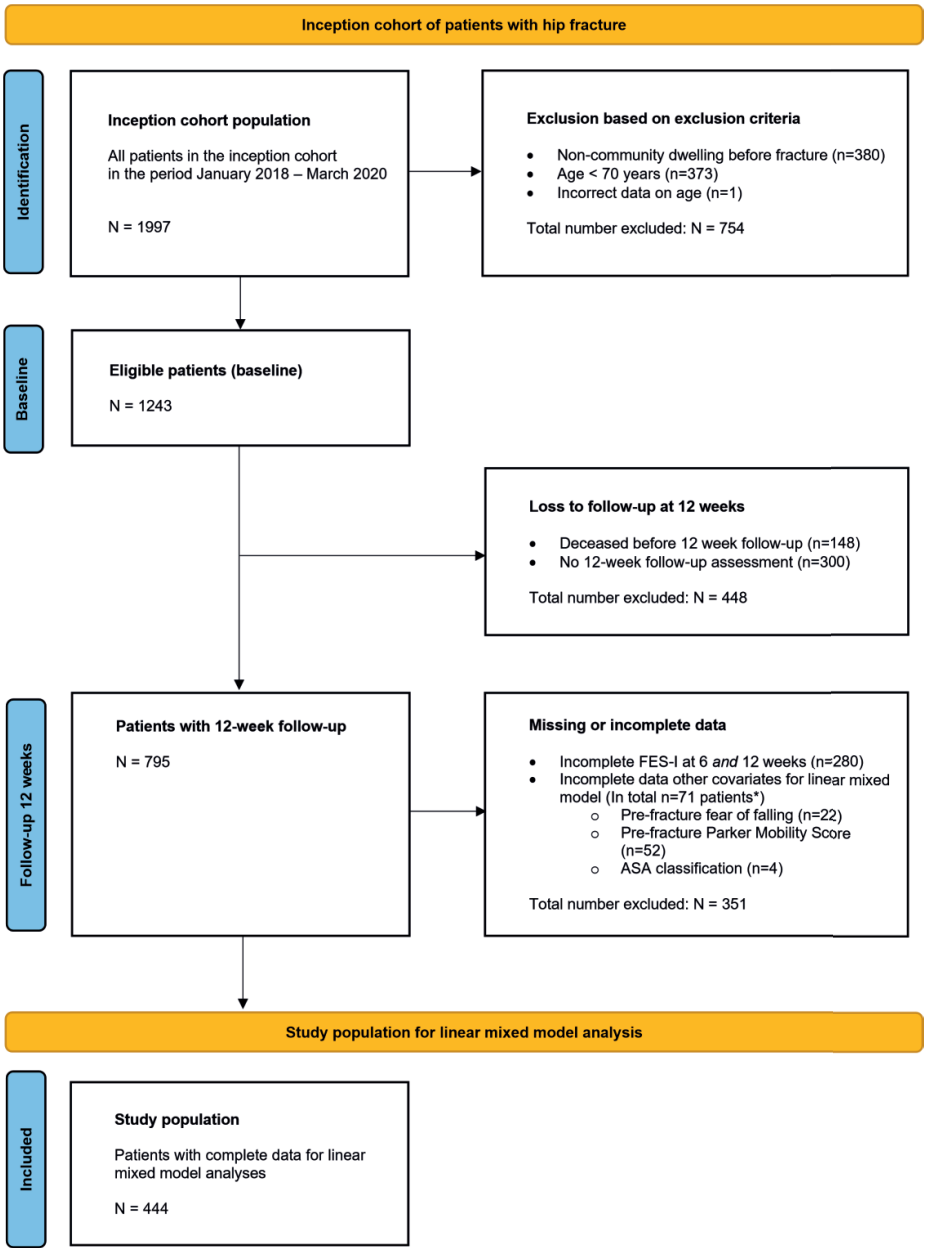
Outcomes are presented as parameter estimates of the linear mixed models. In addition, we present estimated mean FES-I scores at 6, 12, and 52 weeks after fracture for subgroups of our sample. The course of FoF is illustrated in graphs for a patient with sample average values of all covariates. All statistical analyses were performed using IBM SPSS version 25.0 (Windows), graphs were constructed in R version 4.1.0.

RESULTS

The study population consisted of all 444 patients with complete data for all variables required for the analyses (Figure 1). Most patients were female (n=305; 68.7%) and the average age was 81.9 years (SD: 7.1) (Table 1). Prior to the fracture, a considerable proportion of the population had experienced FoF (n= 189; 42.6%). Classification by FoF trend groups shows that absence of FoF is common (no FoF trend group n=190; 42.8%), as is persistent FoF (n=119; 26.8%). Transient FoF accounts for 16.9% (n=75), and late-onset FoF for 13.5% of the population (n=60).

Our final study population (n=444) was younger (Δ= -2.5 years [95% CI: -3.4- -1.7]; p <0.001), had a higher pre-fracture score for the PMS (Δ= 1.6 [95% CI: 1.4-1.9]; p <0.001), and a slightly lower ASA score (Δ= -0.2 [95% CI: -0.2 - -0.1]; p <0.001), as compared to patients that were excluded due to missing data for relevant variables (n=799) (Figure 1).

Figure 1. Flow chart of the study



* Note: multiple missing measurements per patient possible

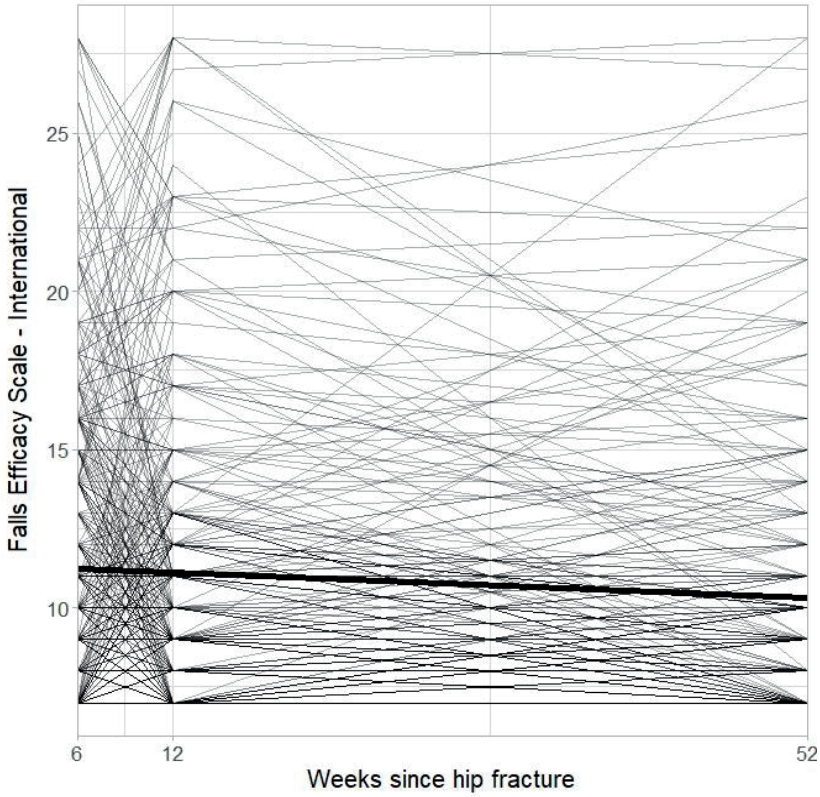
Table 1. Baseline characteristics of the study population (n=444)	
Socio-demographic characteristics	
Age at time of fracture (years); mean (SD)	81.9 (7.1)
Female gender; n (%)	305 (68.7)
Pre-fracture health status (baseline assessments); n (%)	
Patients with ASA Physical Status Classification > II *	234 (52.7)
Nutritional status - based on Mini Nutritional Assessment (MNA)†	
Patients with MNA score 0-7 (malnutrition)	9 (2.2)
Patients with MNA score 8-11 (risk of malnutrition)	93 (22.6)
Cognitive functioning †	
Patients with pre-fracture diagnosis dementia	6 (1.4)
Patients with pre-operative 6-CIT score > 10 *	35 (8.1)
Patients with pre-fracture fear of falling ‡	189 (42.6)
Pre-fracture physical functioning (baseline assessments)	
KATZ-ADL (0-6); median (IQR) *	0.0 (0.0-1.0)
Parker Mobility Scale (0-9); median (IQR) §	9.0 (6.0-9.0)

Notes: ASA classification=American Society of Anesthesiologists classification; 6-CIT=6-Item Cognitive Impairment Test; KATZ-ADL=Katz Index of Independence in Activities of Daily Living; SD=standard deviation; IQR=interquartile range. * Lower scores indicate better status. † Numbers do not add up to final numbers due to missing data, valid % are shown. ‡ Pre-fracture fear of falling was assessed using a one-item fear of falling question ('*Are you afraid of falling?*'), related to the period directly before fracture. Answer categories: '*Not at all*', '*A little*', '*Quite a bit*' and '*Very much*'; of which the 3 latter answers were categorized as 'pre-fracture fear of falling'. § Higher scores indicate better status.

The unconditional growth model demonstrates that the course of FoF up to a year after hip fracture is characterized by a study population-based mean FES-I level that starts just above the cut-off value of 11 at 6 weeks after fracture, and shows a marginal decline over time (Figure 2). Estimates are presented in Appendix 1. One year after fracture, almost one-third of the patients have elevated FES-I levels (n=132; 29.7%). In view of the individual observed trajectories, we see a considerable degree of heterogeneity.

Analyses of FoF trajectories for patients with pre-fracture FoF (n=189) compared to those without it (n=255), show a decrease in FES-I levels for both groups (Figure 3). However, the mean FES-I for the group with pre-fracture FoF is above the cut-off value of 11 during the entire follow-up, as opposed to the group without pre-fracture FoF (values presented in Appendix 2). Although patients with FoF prior to fracture had higher FES-I levels, the effect of pre-fracture FoF on the course of post-fracture FoF was not significant (estimate 0.78; p=0.067).

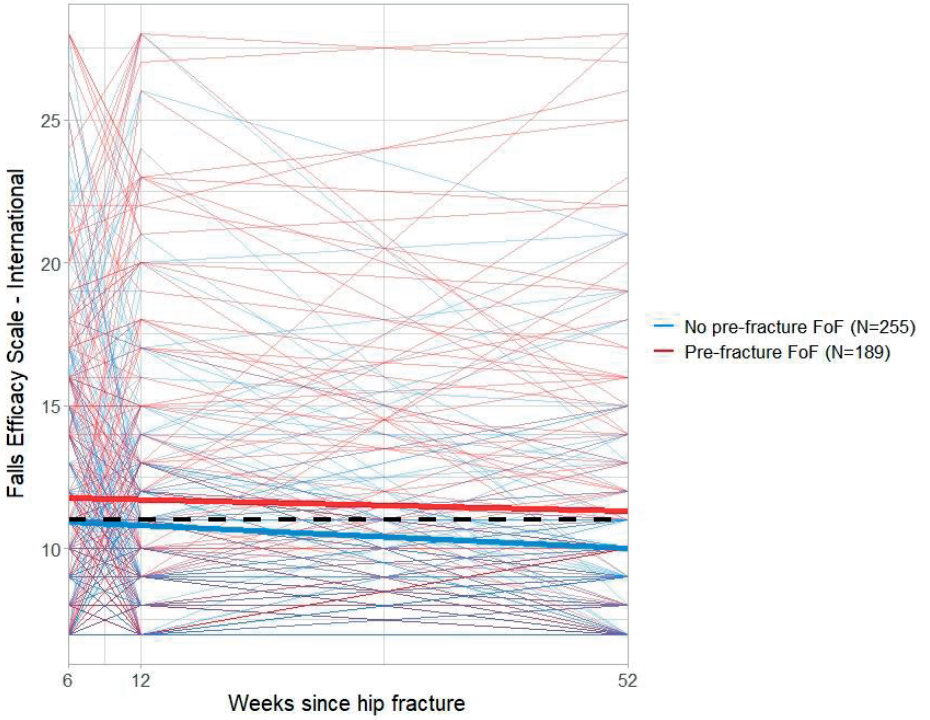
Figure 2. Course of fear of falling up to one year after hip fracture



Notes: Falls Efficacy Scale International (7-item) with range 7-28; lower scores indicating less fear of falling. Accentuated line represents the estimated mean FES-I score for the whole population (n=444). Based on the unconditional linear mixed-model with mean-centred values for covariates. Thin lines represent observed FES-I trajectories of the individual patients.

Figure 4 illustrates the FoF trajectories for each of the four FoF trend groups and shows that each group has a distinct evolution of FoF over time, with different rates of change. The *persistent FoF* trend group has the highest FES-I levels, and although this decreases to some extent over time, levels remain above the cut-off value of 11 during the entire follow-up (estimated mean FES-I: 16.6 at 12 weeks and 14.1 at 52 weeks after fracture). Similarly, the course for the *late-onset* trend group is characterized by an elevated estimated mean FES-I score, yet levels are lower than in the *persistent FoF* group and approach the cut-off value of 11 around 52 weeks after fracture. Both the *no FoF* trend group and *transient FoF* group have FES-I levels well below the cut-off in the period 12-52 weeks. The heterogeneity in the individual observed trajectories is most profound for the *persistent FoF* and *transient FoF* groups (Appendix 3).

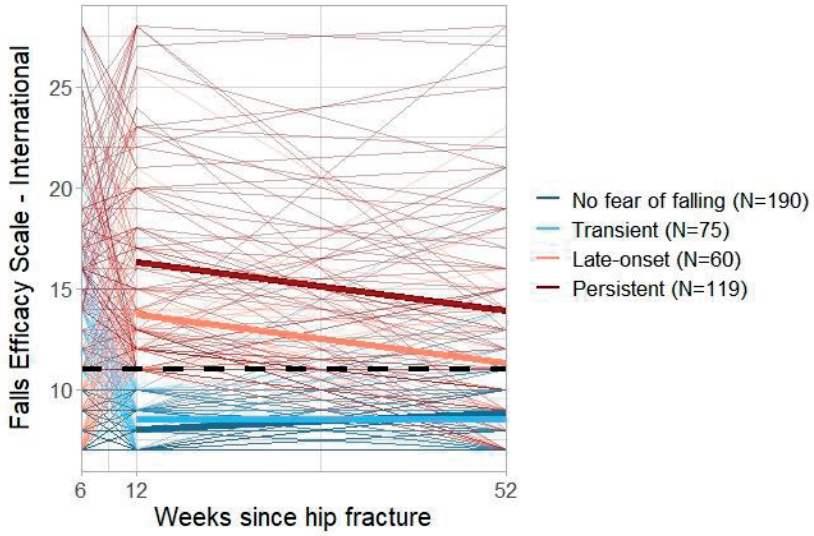
Figure 3. Course of fear of falling up to one year after hip fracture, for patients with or without pre-fracture fear of falling.



Notes: FoF=fear of falling. Falls Efficacy Scale International (7-item) with range 7-28; lower scores indicating less fear of falling. Accentuated solid lines (blue and red) represent the estimated mean FES-I score for the two groups; based on LMM1. The mean FES-I presented in this graph is based on mean-centred values for covariates. It thus represents the course of FoF of a patient with versus *without* pre-fracture FoF, and sample mean values for all other covariates (e.g. age 81.9 years). The dotted black line represents the FES-I cut-off value of 11. The thin coloured lines represent observed FES-I trajectories of individual patients.

In Appendix 4, characteristics of each of the FoF trend groups are presented, including baseline characteristics, and data on outcome after fracture. Prior to fracture, both the *persistent FoF* and *late-onset FoF* group had more health problems, and reduced mobility function. Twelve weeks after fracture, one third of patients in the *persistent FoF* group had a successful recovery regarding independence in ADL function, compared to half of the patients in the *transient FoF* and *late-onset FoF* groups, and almost 80 percent in the *no FoF* group. Insight into the long-term recovery rate is somewhat limited as a result of missing data for a quarter of the population at one year after fracture (Appendix 5). However, the results do point toward better recovery rates for the *No FoF* group as compared to the other three groups that had FoF at 6 and/or 12 weeks after fracture. We evaluated the proportion of patients with FoF (elevated FES-I levels) one year after fracture, based on the estimated FES-I derived from LMM2. FoF was most mostly present in the *late-onset* FoF (n=26; 43.3%) and the *persistent FoF* groups (n=101; 84.9%).

Figure 4. Fear of falling trajectories for pre-defined 'fear of falling trend groups'



Notes: FoF = fear of falling. Falls Efficacy Scale International (7-item) with range 7-28; lower scores indicating less FoF. Accentuated coloured solid lines represent the estimated mean FES-I score for the different FoF trend groups, based on LMM2. The mean FES-I presented in this graph is based on mean-centred values for covariates. It thus represents the course of FoF of a patient within each of the four FoF trend groups, with sample mean values for all other covariates (e.g. age 81.9 years). The dotted black line represents the FES-I cut-off value of 11. The thin coloured lines represent observed FES-I trajectories of individual patients.

The four FoF trend groups were defined based on the presence/absence of fear of falling at 6 *and* 12 weeks. No FoF = FES-I < 11 at 6- and 12-week follow-up; Transient FoF = FES-I ≥ 11 at 6 weeks and FES-I < 11 at 12-week follow-up; Late-onset FoF = FES-I < 11 at 6 weeks and ≥ 11 at 12-week follow-up; Persistent FoF = FES-I ≥ 11 at 6- and 12-week follow-up.

DISCUSSION

Main findings

This is the first study to evaluate FoF up to 12 months after hip fracture. The findings illustrate that the population-based mean FES-I is located around the current established cut-off value of 11, and that levels decrease only slightly over time. However, individual patient trajectories are heterogeneous and amidst this diversity, certain subgroups are noteworthy in view of the elevated FES-I levels. Patients with FoF prior to the hip fracture on average had higher FES-I levels during the entire follow-up period, yet this association between pre-fracture and post-fracture FoF was just above the significance threshold. FoF trend groups analyses show that both the *persistent FoF* group (FES-I elevated at 6 and 12 weeks after fracture) and the *late-onset FoF* group (FES-I elevated at 12 weeks after fracture), have a long-term course characterized by elevated FES-I levels. The *persistent FoF* group – accounting for a quarter of the population – has the most profound levels, with mean FES-I remaining well above the cut-off value of 11 up to one year after fracture.

Strengths and limitations of the study

An important strength of this study is that, owing to the longitudinal design with one-year follow-up, it provides novel insight into the long-term course of FoF after hip fracture. The findings contribute to filling an important knowledge gap in hip fracture research. FoF can be considered a potentially modifiable risk factor, that, when addressed adequately, has the potential to improve functional outcome for this vulnerable population. Findings from this study can assist in identifying an appropriate target population for intervention. An additional strength is that the study design is based on a large inception cohort (without in- or exclusion criteria), increasing the generalizability of the results to a broad population of patients with hip fracture.

However, some limitations of this current study should be considered. First, the analyses were based on a subpopulation – patients with complete cases of FES-I scores at 6 and 12 weeks. This reflects a population that survived the first three months after fracture, was able to visit the out-patient clinic, and did not have severe cognitive deficits that could interfere with the assessment of the FES-I. Patients with advanced cognitive problems or serious physical and functional impairment (i.e., residing in nursing home) may be underrepresented in this population. Indeed we found significant differences between the selected and excluded population regarding the covariates in our model – age, ASA classification, Parker Mobility Score. However, for age and ASA the differences may be considered modest, and we can question the clinical relevance. Second, pre-fracture FoF was assessed in retrospect, which in theory could lead to recall bias. This was also assessed using a one-item fear of falling question, which complicated the comparison between pre-fracture and post-fracture FoF. Future studies should preferably use FES-I for all assessments, in order to enable comparison of the *extent* of FoF before and after fracture, and hence improve insight into the course of FoF, with the fracture as an intermediate event. Finally, we did not assess mood and anxiety in the present study. In community-dwelling older adults depression has been associated with FoF (and activity restriction) [36]. In recent FoF literature it has also been suggested that anxiety determines whether FoF becomes maladaptive [37]. Neuroticism has also been identified as a risk factor for high FoF after fracture [22]. We recommend that future studies evaluate these psychological factors in relation to the course of FoF.

Comparison with current literature on fear of falling

We can question whether FoF, in patients with hip fracture, may to some extent be a normal or adaptive response to the recent fall-related medical event and current physical impairment. Oshima et al. found that for community-dwelling older adults, mobility problems (standing balance and gait) were associated with the development of FoF [38]. This concept may also be applicable for the early stage after fracture, which is characterized by sudden impairment of gait function. This could partly explain our finding that, shortly after hip fracture, the mean FES-I is located around the cut-off value. Another important finding in literature is that the negative

effects of FoF on functional recovery are not found for FoF in the very early phase after hip fracture, but only from 6 weeks after fracture and beyond [13,14]. How this finding relates to the natural course of FoF after fracture is still unknown, owing to a research gap on this subject. Longitudinal data on FoF after hip fracture is scarce and current literature focuses mainly on the cross-sectional presence of FoF. Only two longitudinal studies provide some insight into FES-I levels over time. Similar to our findings, the population-based mean FES-I levels in these studies were ≥ 11 in the early stage after hip fracture. Furthermore, in these studies FoF levels were found around the FES-I cut-off score, at 12 weeks after fracture [22], and 6 months after rehabilitation respectively [39]. This supports the overall course of FoF observed in our study.

However, as our findings demonstrate a considerable degree of heterogeneity in the individual trajectories, it seems helpful to explore specific subgroups, in order to identify patients with 1] excessive FoF, or 2] persistent FoF. Both features could be indicative of *maladaptive* FoF in this population, i.e., FoF that impedes physical activity and daily functioning. To examine whether FoF at 12 weeks is related to an increased risk of FoF in the long term (one year after fracture), we explored FoF trajectories from 12 weeks onward, for the four different trend groups, based on observed FoF at 6 and 12 weeks. Only one previous study evaluated specific FoF trajectories, but within an earlier timeframe, i.e., in the period 4-12 weeks after fracture [22]. Using latent class analysis to model the course, the study found three distinct FoF trajectories, namely *minimal FoF* (72%), *decreasing FoF* (17%) and *increasing FoF* (11%). Despite differences in timeframe and methodology, some parallels can be drawn between study findings. First, a considerable part of the population either has low FES-I levels, or moderate FoF levels around the FES-I cut-off of 11. Second, there is a small group with elevated FES-I levels in the early stage after fracture (4-6 weeks) who demonstrate a trend of recovery in the subsequent period (*decreasing FoF* group respectively *transient FoF* trend group in our study). Third, patients with a trajectory characterized by repeated elevated FES-I levels up to 12 weeks, have substantial levels at onset (4-6 weeks after fracture), with a mean FES-I around 16. A novel finding of our study is that patients in this group with *persistent FoF* have the poorest recovery of independence in ADL function, with only a third of the patients showing successful recovery at 12 weeks after fracture. However, it is noteworthy that recovery for the other groups with FoF, i.e., the transient FoF group with FoF at 6 weeks and late-onset FoF group with FoF at 12 weeks after fracture, is somewhat limited too.

This study also examined pre-fracture FoF in relation to the FoF after fracture, as it is undetermined whether pre-fracture and post-fracture FoF can be considered a continuum. At present, there is no comparative literature on this topic, although one previous study provides evidence that pre-fracture FoF affects short-term functional recovery [12]. Our findings illustrate that, contrary to those without pre-fracture FoF, patients with pre-fracture FoF have sustained elevated FES-I levels over time. Although the association was not statistically significant, the

observed difference between groups with and without pre-fracture FoF indicates that pre-fracture FoF may to some extent influence FoF after fracture, and that it may be relevant to assess this in clinical practice.

Implication for clinical practice

When FoF is evident and impairs daily functioning, existing treatment approaches for community-dwelling older adults are recommended [18,19]. Functional recovery of lower extremity function after hip fracture can continue to almost a year after fracture [40], and we therefore expect that treatment for FoF in advanced stages after hip fracture has potential to optimize functional ability. Considering the high FES-I levels, the chronic nature of the FoF, and the poor recovery of independence in ADL function in the *persistent FoF* trend group, we believe that it is mainly this group - roughly a quarter of the population - that is at risk for *maladaptive* FoF and could consequently benefit from intervention. Timely identification of these patients requires a structural approach to assessing FoF up to at least 12 weeks after fracture. This may call for efforts from various health care professionals in the different care settings that the patient passes through in the rehabilitation process. Essentially, we recommend screening for pre-fracture FoF immediately after fracture to limit risk of recall bias, to assess the FoF levels in the acute phase, at onset of rehabilitation, and at 12 weeks after fracture.

CONCLUSION

Although FES-I levels decrease to some extent in the year following hip fracture, FoF as defined by a FES-I score ≥ 11 remains present over time for a considerable part of the population. Patients with persistent FoF at 12 weeks have the highest FES-I levels during the entire follow-up, a high rate of FoF one year after fracture, and limited recovery of independence in ADL function. These patients may benefit from an intervention to address the FoF. To identify patients at risk for high or persistent FoF in a timely manner, we therefore recommend structural assessment of FoF, including screening for (pre-fracture) FoF directly after fracture, at onset of rehabilitation, and 12 weeks after fracture.

What is already known on this topic

- Fear of falling (FoF) is common after hip fracture, and when it is present in the period 6 weeks after fracture and beyond, it can hamper functional recovery
- In contrast to positive effects seen for treatment of community-dwelling older adults, the evidence in support of treatment of FoF shortly after hip fracture is inconclusive
- The long-term course of FoF after hip fracture is unknown

What this study adds

- In the first year after hip fracture, the FoF levels decrease somewhat overall, yet elevated FES-I levels remain common
- Highest FES-I levels are observed for patients with persistent FoF at 6 *and* 12 weeks post-fracture, with levels well above the cut-off value during the year following fracture. Recovery of ADL independence is poor for patients with persistent FoF.

DECLARATIONS

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Contributor and guarantor information

MvdS and AN designed the current data collection structure for this inception cohort and monitored the data collection. AN and MvE are regularly involved in the data-collection of this ongoing inception cohort. MSB performed the data-analysis, together with MH and MvE. MSB, MH, WA, JvH and MvE were involved in the interpretation of the results. MSB drafted the manuscript. All authors contributed to the manuscript, provided feedback, and have read and approved the final version. MSB is the guarantor. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Data sharing

The dataset used for the purpose of this study are available from the corresponding author on reasonable request.

Ethical approval

The Medical Research Ethics Committee of the Haaglanden Medical Center, and the hospital's board of directors approved the study protocol of the inception cohort (METC Southwest Holland; protocol number 16-059). Because of its observational design, informed consent was not required according to the Dutch regulations.

Transparency statement

The lead author (MSB) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Competing interests declaration

All authors declare they have no conflicts of interest.

Patient and Public Involvement

There was no patient and public involvement in any stage of this study.

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APPENDIX

Appendix 1. Results of linear mixed-model analyses to describe the course of fear of falling after hip fracture (n=444)

Parameter	Unconditional model			Model 1: pre-fracture fear of falling			Model 2: fear of falling trend groups		
	Estimate	95% CI	P-value	Estimate	95% CI	P-value	Estimate	95% CI	P-value
Fixed effects *									
Intercept	11.37	[10.98; 11.77]	0.000	11.04	[10.51; 11.57]	0.000	7.81	[7.29; 8.32]	0.000
Linear rate of change/week (slope)	- 0.02	[-0.03; -0.01]	0.000	- 0.02	[-0.04; 0.01]	0.000	0.02	[0.00; 0.03]	0.015
Pre-fracture fear of falling									
Absent				Reference category			Reference category		
Present				0.78	[-0.06; 1.62]	0.067	0.26	[-0.45; 0.97]	0.479
Interaction with time				0.01	[-0.01; 0.03]	0.183	0.02	[0.00; 0.04]	0.024
Fear of falling trend groups									
No fear of falling							Reference category		
Transient fear of falling							0.74	[-0.24; 1.72]	0.141
Interaction with time							-0.02	[-0.05; 0.01]	0.254
Late-onset fear of falling							6.66	[5.60; 7.73]	0.000
Interaction with time							-0.08	[-0.11; -0.05]	0.000
Persistent fear of falling							9.24	[8.38; 10.10]	0.000
Interaction with time							-0.08	[-0.11; -0.06]	0.000
Random effects									
Intercept (initial FES-I value)	10.13	[8.41; 12.21]	0.000	9.91	[8.22; 11.96]	0.000	4.21	[3.10; 5.72]	0.000
Residual covariance †									
6 weeks	11.12	[9.30; 13.30]	0.000	11.15	[9.33; 13.33]	0.000	‡	‡	‡
12 weeks	8.95	[7.32; 10.93]	0.000	9.03	[7.40; 11.02]	0.000	4.41	[3.28; 5.92]	0.000
52 weeks	7.02	[5.45; 9.04]	0.000	6.86	[5.32; 8.85]	0.000	7.75	[6.22; 9.65]	0.000

In all models, time is operationalized as weeks since hip fracture. * All 3 models are adjusted for (mean-centred) age, ASA classification and pre-fracture Parker Mobility Score. † Diagonal covariance structure for repeated measures. ‡ Not applicable, the course for model 2 is modelled from 12 weeks onward, as this model included the independent variable 'FoF trend groups', which was based on the observed FES-I at 6 and 12 weeks.

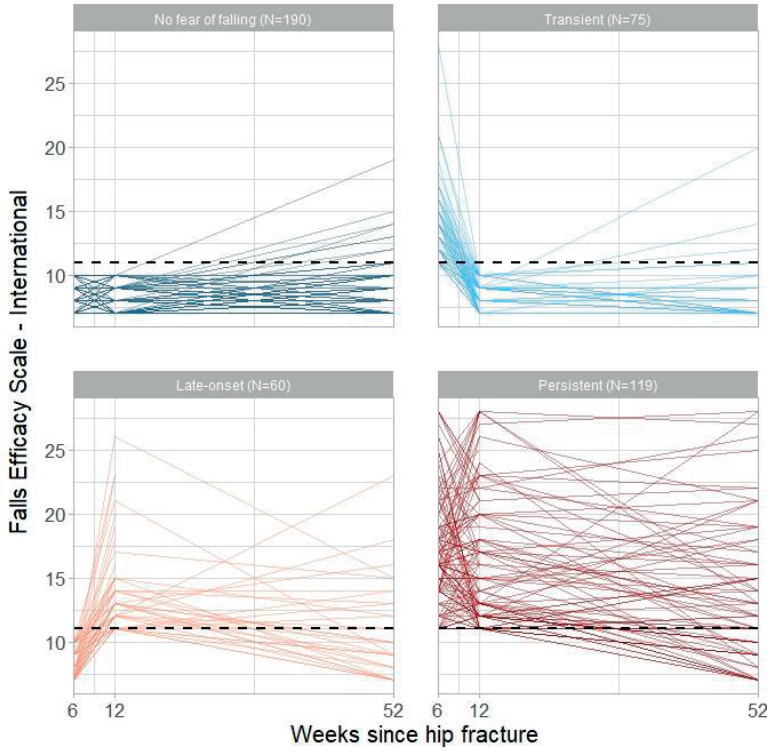
Appendix 2. Course of fear of falling after hip fracture – estimated mean FES-I* in the period up to 52 weeks after hip fracture

LMM1 – Pre-fracture fear of falling †			
	Estimated mean FES-I †		
Pre-fracture FoF (total n=444)	6 weeks after hip fracture	12 weeks after hip fracture	52 weeks after hip fracture
No pre-fracture FoF (n=255)	10.5 (2.6)	10.3 (2.6)	9.4 (2.6)
Pre-fracture FoF present (n=189)	12.3 (3.6)	12.3 (3.6)	11.9 (3.6)

LMM2 – Fear of falling trend group †			
	Estimated mean FES-I †		
FoF trend group (total n=444) §	6 weeks after hip fracture	12 weeks after hip fracture	52 weeks after hip fracture
No FoF (n=190)	‡	7.8 (0.7)	8.4 (1.0)
Transient FoF (n=75)	‡	8.5 (0.7)	8.5 (1.0)
Late-onset FoF (n=60)	‡	13.8 (1.7)	11.3 (1.9)
Persistent FoF (n=119)	‡	16.6 (2.8)	14.1 (3.0)

Notes: LMM=linear mixed model; FoF=fear of falling. * FES-I=Falls Efficacy Scale International (7-item); range 7-28; lower scores indicating less fear of falling. † Analysis based on linear mixed model. Models include fixed intercept and a random intercept, in addition to the covariates age, ASA classification and pre-fracture Parker Mobility Score (all mean-centred). LMM 1 includes pre-fracture FoF as a predictor for the intercept and the slope. LMM 2 includes both pre-fracture FoF and FoF trend group as intercept and slope predictors. § FoF trend groups based on the observed FES-I scores at 6 and 12 weeks follow-up. *No FoF* = FES-I < 11 at 6- and 12-week follow-up. *Transient FoF* = FES-I ≥ 11 at 6 weeks and FES-I < 11 at 12-week follow-up. *Late-onset FoF*= FES-I < 11 at 6 weeks and ≥ 11 at 12-week follow-up. *Persistent FoF* = FES-I ≥ 11 at 6- and 12-week follow-up. ‡ Not applicable, LMM 2 is based on FES-I data from 12 weeks to 52 weeks after fracture.

Appendix 3. Fear of falling after hip fracture – observed FES-I values for the four 'FoF trend groups'



Notes: FoF=fear of falling. Falls Efficacy Scale International (7-item) with range 7-28; lower scores indicating less FoF. The dotted black line represents the FES-I cut-off value of 11. The thin coloured lines represent observed FES-I trajectories of individual patients.

The four FoF trend groups were defined based on the presence /absence of fear of falling at 6 and 12 weeks. No FoF = FES-I < 11 at 6- and 12-week follow-up; Transient FoF = FES-I ≥ 11 at 6 weeks and FES-I < 11 at 12-week follow-up; Late-onset FoF = FES-I < 11 at 6 weeks and ≥ 11 at 12-week follow-up; Persistent FoF = FES-I ≥ 11 at 6- and 12-week follow-up.

Appendix 4. Characteristics of the four distinct fear of falling (FoF) trend groups (total n=444)†

	No FoF n=190 (42.8%)	Transient FoF n=75 (16.9%)	Late-onset FoF n=60 (13.5%)	Persistent FoF n=119 (26.8%)
Baseline characteristics				
Age at time of fracture (years); mean (SD)	80.6 (6.7)	82.2 (7.3)	83.3 (8.2)	83.3 (6.8)
Female gender; n (%)	128 (67.4)	45 (60.0)	43 (71.7)	89 (74.8)
Pre-fracture health status (baseline assessments); n (%)				
Patients with ASA Physical Status Classification > II ‡	82 (43.2)	44 (58.7)	33 (55.0)	75 (63.0)
Nutritional status - based on Mini Nutritional Assessment (MNA) *				
Patients with MNA score 0-7 (malnutrition)	1 (0.6)	1 (1.4)	1 (1.9)	6 (5.5)
Patients with MNA score 8-11 (risk of malnutrition)	33 (18.5)	13 (18.1)	16 (30.2)	31 (28.4)
Cognitive functioning				
Patients with pre-fracture diagnosis dementia *	3 (1.6)	0 (0.0)	1 (1.7)	2 (1.7)
Patients with pre-operative 6-CIT score > 10 ‡	11 (5.9)	8 (10.8)	6 (10.3)	10 (8.8)
Patients with pre-fracture fear of falling **	65 (34.2)	34 (45.3)	23 (38.3)	67 (56.3)
Pre-fracture physical functioning (baseline assessments)				
ADL function - KATZ-ADL score (0-6); median (IQR) ‡	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-2.0)	0.0 (0.0-2.0)
Mobility - Parker Mobility Scale (0-9); median (IQR) §	9.0 (7.0-9.0)	9.0 (7.0-9.0)	7.0 (6.0-9.0)	6.0 (6.0-9.0)
Outcomes after hip fracture				
Recovery of independence in ADL ††; n(%) *				
Patients with successful recovery - 6 weeks after fracture	99 (52.9)	23 (31.5)	12 (21.1)	29 (24.8)
Patients with successful recovery - 12 weeks after fracture	148 (79.1)	41 (54.7)	30 (50.8)	43 (36.4)
Patients with successful recovery - 52 weeks after fracture	115 (78.2)	26 (59.1)	22 (48.9)	44 (47.8)
Fear of falling; n (%)				
Patients with elevated estimated FES-I (≥11) ‡‡ - 52 weeks after fracture	1 (0.5)	1 (1.3)	26 (43.3)	101 (84.9)

Appendix 4. Characteristics of the four distinct fear of falling (FoF) trend groups (total n=444)†
Notes: FoF=fear of falling; ASA classification=American Society of Anesthesiologists classification; 6-CIT=6-Item Cognitive Impairment Test; KATZ-ADL=Katz Index of Independence in Activities of Daily Living; ADL=Activities of Daily Living; FES-I=Falls Efficacy Scale International; SD=standard deviation; IQR=interquartile range.
† FoF trend groups based on the observed FES-I scores at 6 and 12 weeks: 1] No FoF = FES-I < 11 at 6- and 12-week follow-up; 2] Transient FoF = FES-I ≥ 11 at 6 weeks and FES-I < 11 at 12-week follow-up; 3] Late-onset FoF = FES-I < 11 at 6 weeks and ≥ 11 at 12-week follow-up; and 4] Persistent FoF = FES-I ≥ 11 at 6- and 12-week follow-up. * Numbers do not add up to final numbers due to missing data, valid % is shown. ‡ Lower scores indicate better status. § Higher scores indicate better status. ** Pre-fracture fear of falling was assessed using the one-item fear of falling question ("*Are you afraid of falling?*"), related to the period directly before fracture. Answer categories: "*Not at all*", "*A little*", *"Quite a bit"* and *"Very much*"; of which the 3 latter answers were categorized as 'pre-fracture fear of falling'. †† Recovery of independence in ADL = combined outcome measure based on the following variables: 1] mortality; 2] (in)dependent living situation; and 3] recovery of ADL function to pre-fracture level, measured with KATZ-ADL. Successful recovery was operationalized as: no mortality (all causes) + living independently in a private residence (including a residential home setting, and as needed with home care) + recovery to pre-fracture ADL function (current KATZ ADL ≤ pre-fracture ADL). ‡‡ Estimated FES-I based on the LMM2.

Appendix 5. Missing data in final study population (n=444)

Assessments missing - N	Baseline*	6 weeks after hip fracture	12 weeks after hip fracture	52 weeks after hip fracture
KATZ-ADL	0	0	2	122 ‡
Information regarding current residence	0	10	3	110 ‡
Recovery of independence in ADL §	†	10	5	116
FES-I	†	0	0	170 ‡