Neurological Sciences
https://doi.org/10.1007/s10072-020-04352-2

ORIGINAL ARTICLE

Clinical features of fallers among inpatient subacute stroke: an observational cohort study

Giovanni Morone [1] · Alex Martino Cinnera [2] · Teresa Paolucci [3] · Henson Dianne Reyes Beatriz [4] · Stefano Paolucci [1,2] · Marco Iosa [1]

Received: 19 October 2019 / Accepted: 16 March 2020

Abstract

Background and purpose The aim of this study is to observe the differences between fallers, common fallers, and non-fallers in stroke patients compared with the global ability in a rehabilitation setting.

Materials and methods An observational and prospective study has been carried out. A total of 476 subacute stroke patients have been observed. The main outcome measures were assessed using the Canadian Neurological Scale (CNS), Barthel Index (BI), Functional Ambulatory Category (FAC), and Trunk Control Test (TCT) at admission to the rehabilitation unit and after 90 days of the rehabilitation treatment (nearly 3 h for day for 5 days for week) at the discharge with intermediate evaluations after the first and second months.

Results Out of 397 patients, 109 reported 1 or more falls (27.5%), of whom 67 fell 1 time (fallers) in the hospital (16.9%) and 42 fell 2 or more times (common fallers) (10.6%). For fallers, BI and FAC scores had a significant effect ($p = 0.003$ for both). Common fallers had statistically significant differences in BI ($p = 0.002$), FAC ($p = 0.012$), and TCT scores (0.023) compared with non-fallers.

Conclusions The severity of stroke may directly increase the risk of fall, and also indirectly, lengthening the hospitalization. Our study seems to suggest that patients with BI scores of between 21 and 30 on admission are more prone to fall in the first period of hospitalization, whereas in the second month, those with scores of between 11 and 20 on admission have a higher risk of falls. In the third month, patients with BI scores below 10 on admission are more susceptible to falls.

Keywords Gait · Accidental falls · Postural balance · Rehabilitation · Stroke · Stroke rehabilitation

Introduction

Falls are the most adverse complication in patients who have suffered a stroke event [1]. Stroke survivors develop various impairments, such as cognitive and locomotor deficits, which increase their likelihood of becoming repeat fallers than older populations in general [2, 3]. Falls can have severe consequences, physically and psychosocially. Up to 30% of falls turn into injury, including head and soft tissue traumas and hip fractures [4]. Thus, many studies have examined the risk factors of falling in institutionalized post-stroke patients, to develop preventive measures and treatments that reduce the frequency of this adverse episode.

Decreases in balance and global functions are associated with falls; 1 other finding has highlighted the relevance of cognitive impairments, wherein a cutoff score of 24 on the Mini-Mental State Examination (MMSE) is a predictor of falling [5]. Moreover, urinary incontinence and impaired performance on activities of daily life seemed to increase the likelihood of falls [6]. Despite the various training regimens for improving balance and walking performance and other therapeutic options, the management of the risk of falls in stroke has remained unknown, with no evidence of efficacy, with the exception of the vitamin D assumption [3].

✉ Alex Martino Cinnera
a.martino@hsantalucia.it

1 Clinical Laboratory of Experimental Neurorehabilitation, IRCCS Santa Lucia Foundation, Via Ardeatina, 306, 00179 Rome, Italy

2 Neurorehabilitation Unit F, IRCCS Santa Lucia Foundation, via Ardeatina 354, 00142 Roma, Italy

3 Complex Unit of Physical Medicine and Rehabilitation, Policlinico Umberto I Hospital, Sapienza University of Rome, Rome, Italy

4 Neurorehabilitation Unit B, IRCCS Santa Lucia Foundation, Via Ardeatina, 306, 00179 Rome, Italy

Published online: 07 April 2020

The risk of falling in stroke patients is considerable during hospitalization and rehabilitation [1, 7], ranging from 2.9 to 13 falls per 1000 bed-days [8]. Most falls occur in care settings in the first month, and many patients experience 1 or more falls. Fallers have common factors, such as reduced tone or paralysis, poor cognitive outline; a prescription of 2 or more drugs, especially antiepileptic drugs; and severe walking and balance impairments [5, 9]. Other factors, such as communication and visuospatial disorders, have also been reported [5, 9, 10]. Recent studies have focused on walking ability. Poor locomotor performance is a risk factor, but a difference between short- and long-term walking speed has been found to increase the risk of falling, likely due to a discrepancy in sensory-motor function between one's previous and actual intention and capacity to move [11].

Despite these findings, the number of fallers has remained constant, imposing a significant economic burden on the health care system [7]. Thus, understanding why, when, and how patients fall during inpatient rehabilitation might help to prevent falls and their sequelae and identify patients who are at high risk on discharge—in particular, common fallers [12, 13], who are more prone to severe injuries that are related to falls [14].

Because falls and fall-related injuries have high morbidity and mortality rates, we examined the differences between fallers, common fallers, and non-fallers who have been affected by stroke and the relationship between fallers and common fallers and global ability.

Materials and methods

This observational and prospective study was conducted in the neurological rehabilitation setting of Santa Lucia Foundation Hospital. Patients who were admitted to the rehabilitation unit for multidisciplinary intensive stroke rehabilitation were recruited from January 2010 to December 2017. The inclusion criteria were for subjects who had been affected by a first stroke at age between 18 and 85 years and admitted for multidisciplinary and intensive rehabilitation. The exclusion criteria were MMSE score < 21, sequelae of prior cerebrovascular accidents, or other chronic disabling pathologies and orthopedic injuries that could impair gait function. The protocol was approved by the local independent ethics committee, and all participants provided written informed consent. Patients who met the criteria were enrolled, after which they signed informed consent forms and were observed during their stay. Doctors and nurses had to report each fall to our staff, which collected information about the falls (place, time, circumstance, and consequences). Fall is an "event which results in a person coming to rest inadvertently on the ground or other lower level and other than as a consequence of a violent blow, loss of consciousness or sudden onset of paralysis" [15] which may or may not result in physical injury [16]. The patient or witnesses to the fall had to describe the episode of falling and note the time, circumstances, and consequences.

Patients who were admitted to our intensive rehabilitation unit received the rehabilitation treatment (nearly 3 h/day for 5 days/week). In particular, 2 daily physiotherapy sessions lasting a total of 80 min were performed. Physiotherapy consisted of exercises for the recovery of voluntary motor and balance functions, including muscle stretching, active-assisted mobilizations, progressive neuromuscular facilitation training, balance exercises, and gait training. The data on the patients that we collected included their demographics, the characteristics of their cerebral lesions and consequent impairments, and the length of hospitalization. The following scales were used: Canadian Neurological Scale (CNS) to assess global impairment, Barthel Index (BI) to measure global ability compared with activities of daily living (ADL), Functional Ambulatory Category (FAC) to evaluate walking ability, and Trunk Control Test (TCT) to measure trunk posture control. The consequences of falls were also checked by a radiologists using X-ray instruments to look for possible fractures. The planned recovery was about 90 days for all patients, prolonged in case a worsening occurred during the hospitalization, such as those caused by a fall or by severe deficits at admission. In this scenario, the length of stay is intrinsically related to the possibility of fall and is longer if a fall occurred, in turn increasing the possibility of a second fall. For this study, subjects that fell one time during the observation period were considered "fallers," subjects that fell more than one time are "common fallers," and in the end "non-fallers" were considered subjects who did not fall during the observation period.

Statistical analysis

Data were compared between non-fallers and fallers (including common fallers) and between non-fallers and common fallers. Means and standard deviations were computed for continuous measures (age and length of stay) and compared by Student's t test. Median and inter-quartile ranges (IQR) were computed for ordinal measures (clinical scale scores) and compared by Mann-Whitney U test. Percentages for binary variables (gender, type of stroke, side of stroke) were computed and compared between groups by χ^2 test. Forward stepwise binary logistic regression was used to avoid issues that were related to the multicollinearity of independent variables. Beta, standard error (S.E.), odds ratio (exp(beta)), 95% confidence intervals (95% CI), and the percentage of correct predictions of the regression model were computed. Kaplan-Meier plots were constructed for fallers and common fallers, subdividing subjects by BI score on admission into 6 groups, as in Paolucci et al. [17] (BI score range 0–10, 11–20, 21–30, 31–40, 41–50, and > 50). Differences between groups were analyzed by logrank test.

The efficiency of rehabilitative intervention was computed as the difference in BI scores between dismissal and admission, divided by the length of stay in days. The effectiveness of rehabilitation was calculated as the proportion of potential improvement that was achieved during rehabilitation, per the formula [18]:

$$\frac{(\text{discharge score} - \text{initial score})}{(\text{maximal score} - \text{initial score})} \times 100$$

The estimated BI score at the moment of the fall was defined as the sum of the BI score on admission and the product of the efficacy and the day on which the fall occurred. Because efficacy depended on the BI score at admission, a model was computed for non-faller data to estimate the quadratic relationship between efficacy and BI score on admission. The model for non-faller was computed as follows: the frequencies of fallers and common fallers with regard to estimated BI score were calculated as the number of fallers divided by the entire number of subjects, using the estimated BI score at the moment of the fall for fallers and the BI score on admission for non-fallers. Correlations were computed among variables in terms of Spearman coefficient (R) or partial correlation corrected for length of hospitalization.

Results

Data on 476 patients were collected during the observation period. We eliminated 18 patients from the analyses due to incomplete data, 14 patients due to re-admittance to the hospital after dismissal, and 47 patients due to transfer to another hospital or an emergency hospital for complications that were not linked to a fall. As a consequence, the sample ultimately comprised 397 patients, 109 of whom reported 1 or more falls (27.5%). In detail, 67 patients fell 1 time at the hospital (16.9%), and 42 fell 2 or more times (10.6%); the latter subjects were classified as common fallers.

Falls were more frequent in the first and second weeks of hospitalization (please see Fig. 2) and were more frequent in the late morning hours from 10 am to 2 pm. Falls occurred more frequently in the bedroom and in the bathroom. Three patients reported a fracture as a consequence of their fall.

Table 1 shows the demographic and clinical characteristics of the entire sample, divided into non-fallers, fallers, and common fallers. In general, fallers and non-fallers had similar clinical scale scores on admission, with the exception of FAC scores. Several parameters differed significantly between common fallers and no fallers, including TCT, FAC, and BI scores. Not significant but clear characteristics from non-fallers to fallers, up to common fallers, were observed for CNS score, presence of unilateral neglect, and male gender.

Correlation analysis revealed that the number of falls was significantly correlated with clinical scores assessed at admission of FAC ($R = -0.154$, $p = 0.002$) and then BI ($R = -0.142$, $p = 0.005$) and TCT ($R = -0.127$, $p = 0.012$), and also with the length of stay ($R = 0.110$, $p = 0.028$). If corrected for length of stay, the number of falls remained correlated only with age ($R = 0.262$, $p = 0.006$). However, this finding could mainly be due to the stronger correlation found between length of hospitalization and clinical scale scores at admission: BI ($R = -0.607$, $p < 0.001$), CNS ($R = -0.600$, $p < 0.001$), FAC ($R = -0.557$, $p < 0.001$), TCT ($R = -0.554$, $p < 0.001$), unilateral spatial neglect ($R = 0.217$, $p < 0.001$), and partially with age ($R = 0.108$, $p = 0.032$).

When these factors were dichotomized (for clinical scores using their medians), there was a significant effect of FAC in identifying potential fallers and of BI score in identifying common fallers by binary logistic regression (Table 2). For fallers, in the first step of the analysis, BI and FAC scores had a significant effect ($p = 0.003$ for both), whereas the presence of unilateral neglect ($p = 0.069$) and TCT score ($p = 0.065$) approached the threshold for significance. Because the p values were the same in the first step between BI and FAC scores, a similar goodness of fit for the model was obtained using FAC score instead of BI score ($p = 0.003$, with 71.8% of the explained variance). For common fallers, BI score ($p = 0.002$), FAC score ($p = 0.012$), and TCT score (0.023) were significant in the first step, whereas in the second step, of the variables that remained out of the model for common fallers, only gender had a p value (0.079) that was close to the threshold for significance. Notably, BI score was better in identifying common fallers than fallers, based on the odds ratio (exp(beta) = 2.829 vs. 1.944) and explained variance (87.3% vs. 71.8%).

No significant differences were detected dividing subjects by BI score at admission in terms of number of falls ($p = 0.155$ and $p = 0.433$ for fallers and common fallers, respectively, by Logrank test), possibly due to the change in the most likely fallers over time. For example, in the first month of hospitalization, the most likely common fallers were patients with BI scores at admission of 21–30, followed sequentially by those with scores of 11–20 and 0–10. The progressive increase in Barthel Index has been quantified by the efficacy, which did not differ significantly between fallers and non-fallers but was higher in the latter, for which the mean efficacy was 0.42 ± 0.38 BI points per day.

A significant quadratic relationship between BI on admission and efficacy was observed ($R^2 = 0.189$, $p < 0.001$). The equation to determine BI score on day (N) (i.e., $N = 1$ at admission) was:

Table 1 Demographic and clinical characteristics of the entire sample and divided between non-fallers, fallers and common fallers

	Total sample ($n = 397$)	Non-fallers (F_0) ($n = 285$)	Fallers (F_1) ($n = 109$)	Common fallers (F_{1+}) ($n = 42$)	Analysis, F_0 vs. F_1	Analysis, F_0 vs. F_+
Age (years)	68.2 ± 13.5	67.6 ± 14.3	69.8 ± 10.9	69.8 ± 9.8	0.144	0.344
Sex [M vs. F]	54% vs. 46%	52% vs. 48%	59% vs. 41%	62% vs. 38%	0.262	0.250
Type [I vs. H]	82% vs. 18%	82% vs. 18%	82% vs. 18%	79% vs. 21%	0.946	0.599
Side [L vs. R]	57% vs. 43%	57% vs. 43%	56% vs. 44%	60% vs. 40%	0.860	0.752
Neglect	17%	15%	22%	24%	0.092	0.143
Length of stay	97 ± 41	95 ± 43	103 ± 38	112 ± 49	0.084	*0.017*
CNS	6 (4–8)	6 (4–9)	6 (4–8)	6 (4–8)	0.613	0.084
TCT	36 (12–48)	36 (12–61)	24 (12–48)	24 (0–48)	0.240	*0.010*
FAC	0 (0–1)	0 (0–1)	0 (0–0)	0 (0–0)	*0.039*	*0.008*
BI admission	15 (5–40)	20 (5–45)	10 (5–30)	10 (5–20)	0.179	*0.004*
BI dismissal	55 (35–85)	60 (35–90)	50 (35–70)	50 (30–65)	0.594	0.050
Efficacy BI	0.42 ± 0.38	0.44 ± 0.42	0.38 ± 0.25	0.35 ± 0.22	0.208	0.197
EFC BI	49.2 ± 32.4%	50.5 ± 34.2%	45.9 ± 26.8%	42.6 ± 24.9%	0.210	0.152

Type I, ischemic stroke; *Type H*, hemorrhagic stroke; *CNS*, Canadian Neurological Scale; *TCT*, Trunk Control Test; *FAC*, Functional Ambulation Categories; *BI*, Barthel Index; *EFC*, effectiveness

$$\mathrm{BI}(N) = \mathrm{BI}(1) + \left(-0.0002 \times \mathrm{BI}(1)^2 + 0.0215 \times \mathrm{BI}(1) + 0.1778\right) \times N$$

Based on this model, we estimated the BI score for fallers and common fallers at the moment of the fall. Figure 1 shows the frequencies of fallers and common fallers in the entire sample with regard to the estimated BI score at the moment of the fall. Scores between 11 and 20 were the most dangerous for fallers, vs. between 21 and 30 for common fallers. Finally, Fig. 2 shows the weekly distribution of the first fall in falling patients.

Discussion

The data showed that the 27.5% of inpatients for a stroke fall at least one time, during hospitalization. In general, except for the FAC score, there are no substantial differences between non-fallers and fallers (considering also the subjects who fall only once). Differently, the analysis between common faller and non-faller patients showed significant differences in trunk control, gait, and ability in ADL scores. Consistent with our results, Blennerhassett et al. reported that low clinical scale scores are related to a significant risk of falls. In particular, they identified a cutoff score on the 6-min walking test (< 250 m) that accurately classified the history of falls in 70 to 78% of participants [19]. Prevention of falls in the hospital setting is a key issue in patient safety and public health. Unfortunately, there is little evidence on the factors that contribute to inpatient falls or the effectiveness of hospital fall prevention programs [20]. For common fallers, the Kaplan-Meier trend estimated BI scores at the moment of the fall between 21 and 30 on admission were more prone to the risk of falls in the first period of hospitalization, compared with the second month, in which patients with BI scores between 11 and 20 on admission had a greater risk of falls, which have probably achieved a range between 21 and 30. In the third period, patients with BI scores below 10 were more prone to falls, most of whom likely had scores of between 21 and 30 at the moment of the fall. Common fallers are more prone to serious injuries, requiring the identification of subjects who are at risk and the implementation of strategies to reduce falls [11, 21]. In this respect, these results can be useful, specifically the BI range at admission for stroke patients, to predict falls during recovery and from the

Table 2 Results of binary logistic regression analysis for BI score

Group	β	SE	p	Exp(β)OR	CI 95%		Explained variance (%)
Fallers	0.665	0.226	0.003	1.944	1.294	3.025	71.8
Common fallers	1.040	0.344	0.003	2.829	1.441	5.551	87.3

BI, Barthel Index; β, beta coefficients; *SE*, standard error; *Exp(β)OR*, odds rations of exponential distribution; *CI*, confidence interval

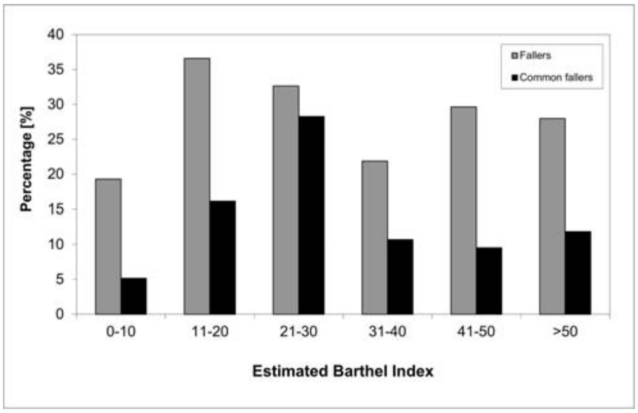

Fig. 1 Percentage of fallers (1 fall) and common fallers (2 or more falls) by estimated Barthel Index scores

perspective of the clinician they can lead to a differentiated rehabilitative proposal with targeted interventions to reduce falls as self-management principles and peer-educators, and exercises with more elements for balance control. It is notable that the predicted month of the fall being a relatively unimportant variable, and on the other hand, our patients' repetitive falls were associated with an increase in the length of recovery, consistent with Wong and colleagues [22]. Notably, physical therapy after a stroke seems to highly contribute to improved functional independence of activities in daily living for BI and increased self-confidence and cognitive function [23]. Moreover, the professionals should never lower the focus on the prevention of falls even in the phase of better patient autonomy and try to work above all on re-learning strategies to move safely and independently.

Conclusion

Common fallers have significantly different levels of trunk competencies (TCT), global activity on admission (BI), and ambulation (FAC), whereas fallers differ from non-fallers only in ambulation, as measured by FAC. Standard BI is an appropriate outcome measure for stroke [24] and also seems a good instrument to predict indicatively the risk of falling in stroke

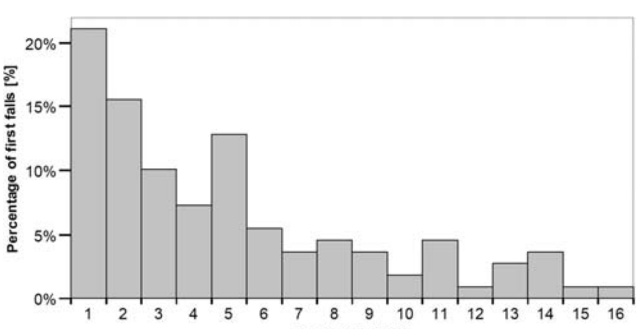

Fig. 2 Weekly distribution of the first fall

patients from the admission to rehabilitation center. Our study seems to show that subjects with BI scores of between 21 and 30 on admission are more likely to suffer from falls in the first period of hospitalization, whereas in the second month, those with scores of between 11 and 20 on admission have a higher risk of falls. In the third period, patients with BI scores below 10 on admission are more susceptible to falls.

Study limitation

A limitation of this study is related to the use of the estimated BI score. Due to the difficulties in measuring the actual BI score before a fall, given the unpredictability of this event, and in recording BI scores daily, we used a model to estimate BI scores. This model was based on the efficacies of parameters that quantify the daily linear increase in BI scores during rehabilitation. Although efficacy is a commonly used parameter, it is conceivable that a bi-exponential trend exists according to motor (re-)learning. Consequently, the relationship between BI score on admission and efficacy was hypothesized to be quadratic. Although this quadratic relationship was statistically significant, it was not possible to exclude more complex relationships between parameters. Thus, the assumptions with regard to the estimation of BI scores might have generated a bias in the data analysis, but the estimated BI scores helped to interpret the results of the Kaplan-Meier plots. However, we found that the side of stroke, in terms of left vs. right hemisphere, did not significantly influence the risk of fall. A limit of our study is the lack of a more specific classification of stroke in terms of its location (such as anterior, posterior, or lacunar circulation infarct) that further studies could take into account. Another potential bias of our study is the unclear relationship among dependent, independent, and control variables. A longer length of hospitalization could be caused by a fall, or increase the possibility of a fall. Furthermore, the severity of stroke (assessed by clinical scales) may directly increase the risk of fall, and also indirectly, lengthening the hospitalization. Because the planned hospitalization in our hospital is equal for all the patients (increased only in case of clinical complications), and given the strengths of tested correlations, a longer length of stay seemed to be more probably caused by a fall, than an indirect cause of it. In the present study, only patients' slight mild cognitive impairment (MMSE > 21) has been selected, since cognitive deficit predictors of the falls would be useful in future studies to analyze their correlation. Further studies conducted in hospitals with different lengths of hospitalization may adopt different mathematical models to clarify the complex relationship between risk of fall and length of stay.

Funding information This work is supported by the Italian Ministry of Health with the Grant Number RC2013G and by IRCCS Santa Lucia foundation.

Compliance with ethical standards

Conflict of interest The authors declare they have no conflict of interest.

Ethical approval The protocol was approved by the local independent ethics committee, and all participants provided written informed consent.

Disclaimer The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

References

1. Teasell R, McRae M, Foley N, Bhardwaj A (2002) The incidence and consequences of falls in stroke patients during inpatient rehabilitation: factors associated with high risk. Arch Phys Med Rehabil 83(3):329–333
2. Divani AA, Vazquez G, Barrett AM, Asadollahi M, Luft AR (2009) Risk factors associated with injury attributable to falling among elderly population with history of stroke. Stroke. 40(10):3286–3292
3. Verheyden GS, Weerdesteyn V, Pickering RM et al (2013) Interventions for preventing falls in people after stroke. Cochrane Database Syst Rev 5:CD008728
4. Ash KL, MacLeod P, Clark L (1998) A case control study of falls in the hospital setting. J Gerontol Nurs 24(12):7–15
5. Saverino E, Benevolo M, Ottonello E, Zsirai P (2006) Sessarego. Falls in rehabilitation setting; functional independence and fall risk. EURA MEDICOPYHS 42(3):179–184
6. Campbell GB, Matthews JT (2010) An integrative review of factors associated with falls during post-stroke rehabilitation. J Nurs Scholarsh 42(4):395–404
7. Langhorne P, Stott DJ, Robertson L, MacDonald J, Jones L, McAlpine C (2000) Medical complications after stroke. Stroke. 31(6):1223–1229
8. Oliver D, Daly F, Martin FC, McMurdo ME (2004) Risk factors and risk assessment tools for falls in hospital in-patients: a systematic review. Age Ageing 33(2):122–130
9. Damián J, Pastor-Barriuso R, Valderrama-Gama E, de Pedro-Cuesta J (2013) Factors associated with falls among older adults living in institutions. BMC Geriatr 13:6
10. Tsur A, Segal Z (2010) Falls in stroke patients: risk factors and risk management. Isr Med Assoc J 12(4):216–219
11. Morone G, Iosa M, Pratesi L, Paolucci S (2014) Can overestimation of walking ability increase the risk of falls in people in the subacute stage after stroke on their return home? Gait Posture 39(3):965–970
12. Mackintosh SF, Hill KD, Dodd KJ, Goldie PA, Culham EG (2006) Balance score and a history of falls in hospital predict recurrent falls in the 6 months following stroke rehabilitation. Arch Phys Med Rehabil 87(12):1583–1589
13. Forster A, Young J (1995) Incidence and consequences of falls due to stroke: a systematic inquiry. BMJ 311(6997):83–86
14. Nevitt MC, Cummings SR (1991) Risk factors for injurious falls: a prospective study. J Gerontol 46(5):M164–M170
15. Kellogg International Work Group on the Prevention of Falls by the Elderly (1987) The prevention of falls in later life. Dan Med Bull 34(Suppl. 4):1–24
16. Zecevic AA, Salmoni AW, Speechley M, Vandervoort AA (2006 Jun) Defining a fall and reasons for falling: comparisons among the views of seniors, health care providers, and the research literature. Gerontologist. 46(3):367–376
17. Paolucci S, Bragoni M, Coiro P, de Angelis D, Fusco FR, Morelli D, Venturiero V, Pratesi L (2008) Quantification of the probability of reaching mobility independence at discharge from a rehabilitation hospital in nonwalking early ischemic stroke patients: a multivariate study. Cerebrovasc Dis 26(1):16–22
18. Shah S, Vanclay F, Cooper B (1990) Efficiency, effectiveness, and duration of stroke rehabilitation. Stroke. 21(2):241–246
19. Blennerhassett JM, Dite W, Ramage ER, Richmond ME (2012) Changes in balance and walking from stroke rehabilitation to the community: a follow-up observational study. Arch Phys Med Rehabil 93(10):1782–1787
20. Oliver D, Hopper A, Seed P (2000) Do hospital fall prevention programs work? A systematic review. J Am Geriatr Soc 48(12):1679–1689
21. van der Kooi E, Schiemanck SK, Nollet F, Kwakkel G, Meijer JW, van de Port I (2017) Falls are associated with lower self-reported functional status in patients after stroke. Arch Phys Med Rehabil 98(12):2393–2398. https://doi.org/10.1016/j.apmr.2017.05.003
22. Wong JS, Brooks D, Mansfield A (2016) Do falls experienced during inpatient stroke rehabilitation affect length of stay, functional status, and discharge destination? Arch Phys Med Rehabil 97(4):561–566
23. Jalayondeja C, Sullivan PE, Pichaiyongwongdee S (2014) Six-month prospective study of fall risk factors identification in patients post-stroke. Geriatr Gerontol Int 14(4):778–785. https://doi.org/10.1111/ggi.12164
24. Duffy L, Gajree S, Langhorne P, Stott DJ, Quinn TJ (2013) Reliability (inter-rater agreement) of the Barthel Index for assessment of stroke survivors: systematic review and meta-analysis. Stroke. 44(2):462–468

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.