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An Integrative Review of Factors Associated With Falls During Post-Stroke Rehabilitation

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Abstract

Purpose: Our aims were to evaluate evidence of risk factors for falls among patients in stroke rehabilitation and to offer recommendations for clinical practice and future research.
Method: We conducted an integrative review of the literature published from 1990 to 2009 that describes empirical investigations of risk factors for post-stroke falls during inpatient rehabilitation. We searched Medline, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycInfo, and Embase databases, using the search terms "accidental falls," "fall risk," "risk factors," "risk assessment," "stroke," and "cerebrovascular disorders." We extracted information regarding study design, sample, potential risk factors, analytic methods, findings, and limitations from the 14 articles that met our inclusion criteria, and we rated the level of evidence for each study.
Findings: Available empirical evidence points to impaired balance, visuospatial hemineglect, and impaired performance of activities of daily living as risk factors for falls during inpatient rehabilitation for stroke. Associations between falls and cognitive function, incontinence, visual field deficits, and stroke type were less clear, while relationships between falls and age, gender, stroke location, and impaired vision and hearing were not supported.
Conclusions: The relatively sparse literature pertaining to risk factors for falls among stroke rehabilitation inpatients indicates that deficits affecting balance, perception, and self-care significantly increase the likelihood of falls. Particularly intriguing is the less well established role of post-stroke cognition in falls in this population. A conceptual model is needed to guide scientific inquiry and clinical practice in this area.
Clinical Relevance: When clinicians in the inpatient stroke rehabilitation setting evaluate which patients are at greatest risk to fall, stroke-specific risk factors such as impaired balance, visuospatial hemineglect, and self-care deficits may be better predictors than more general risk factors such as age, incontinence, and sensory impairments. Patients with these stroke-specific deficits may benefit from the use of aggressive fall prevention interventions.

Falls are among the most common complications of stroke (Moroz, Bogey, Bryant, Geis, & O'Neill, 2004), which affects 795,000 Americans annually (American Heart Association, 2009) and results in some degree of permanent disability for an estimated 450,000 individuals (Salter, Foley, Jutai, & Teasell, 2007). Stroke-related falls occur at especially high rates in the inpatient rehabilitation setting, where incidence ranges from 20% to 48% (Suzuki et al., 2005), and nearly one-third of those who fall sustain injuries such as fractures and hematomas (Teasell, McRae, Foley, & Bhardwaj, 2002). Other deleterious consequences include decreased physical activity

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related to fear of further falls (Suzuki et al., 2005), decreased falls self-efficacy (the belief that one can independently ambulate without falling), and a diminished sense of dignity (Rapport, Hanks, Millis, & Deshpande, 1998).

Considerable clinical attention has been directed toward fall prevention during inpatient rehabilitation. Nevertheless, incidence of falls and related injuries remains high. Rabadi, Rabadi, and Peterson (2008) reported that approximately 14% of stroke patients fell on a rehabilitation unit despite implementation of an aggressive fall prevention program, resulting in injuries that included two hip fractures and a fatal intracranial hemorrhage.

Identifying stroke patients most prone to fall is necessary in order to target prevention measures appropriately, particularly since the inpatient rehabilitation environment is inherently "high risk." That is, the milieu is intentionally challenging, with clinicians pushing the limits of patients' abilities to facilitate their learning and help them achieve greater functional independence. Current science provides little direction to guide fall risk assessment in this population and setting. Efforts to identify a clinically useful set of risk factors for falls among stroke patients, regardless of setting, have been minimally successful (Ashburn, Hyndman, Pickering, Yardley, & Harris, 2008; Lamb, Ferruci, Volapto, Fried, & Guralnik, 2003; Nyberg & Gustafson, 1996, 1997; Zdobysz, Boradia, Ennis, & Miller, 2005), likely due to methodological issues of sample size and instrumentation.

Clinicians often consider age, gender, urinary incontinence, weakness, and cognitive impairment to be risk factors for falls among stroke patients, yet the scientific basis for these perceptions is unclear. In this article we provide the results of an integrative review of the empirical literature pertaining to fall risk among patients in stroke rehabilitation, and we offer recommendations for clinical practice and future research.

Methods

Inclusion criteria and a plan for data extraction were developed and mutually agreed upon by both authors prior to conducting the integrative review. The first author (Campbell) independently performed a computerized search of the Medline, Cumulative Index to Nursing and Allied Health Literature (CINAHL), PsycInfo, and Embase databases using the search terms "accidental falls," "fall risk," "risk factors," "risk assessment," "stroke," and "cerebrovascular disorders." The searches were limited to articles that involved humans, adults over 18 years of age, and English language publications from 1990 to 2009, yielding 595 articles. The abstracts for research reports among these articles were carefully reviewed to discern whether the study design included examination of potential risk factors for falls following stroke. The resulting 40 articles, which consisted of observational rather than interventional studies, were further screened to identify those focused exclusively on post-stroke inpatient rehabilitation, with a final yield of 11 articles. Reference lists for these 11 articles were then manually searched to identify additional relevant research reports. Three additional articles were identified in this manner.

The level of evidence for each study was ranked using a seven-level scale (Melnyk & Fineout-Overholt, 2005) ranging from Level I (systematic review or meta-analysis of all relevant randomized controlled trials, or evidence-based clinical practice guidelines based on integrative reviews) [Correction added after online publication 13-Oct-2010. Integrative review has been changed to systematic review.] to Level VII (opinion of authorities and reports of expert committees). From each article, we extracted information regarding the sample size and the variables evaluated for their relationship to the occurrence of falls, as well as analytic methods, findings, and limitations. We also assessed the adequacy of information provided that would permit calculation of comparable effect sizes across studies. Further, for each potential risk factor, we noted the number of studies that found a statistically significant relationship with occurrence of falls and the number of studies showing no such statistically significant relationship. A potential risk factor was classified as having strong empirical support if a simple majority of the studies that examined the factor found a significant relationship with falls. Support was deemed weak when the majority of these studies found a nonsignificant relationship. We considered empirical support to be equivocal when the relationship between a potential risk factor and occurrence of falls was approximately evenly divided between studies with significant and nonsignificant results.

Findings

The final sample consisted of 14 empirical studies (**Table**) examining fall risk in inpatient stroke rehabilitation. Collectively, the level of evidence represented by the identified articles was low. Webster and colleagues' (1995) investigation of rightward orienting bias and hemineglect, wheelchair maneuvering, and fall risk represented Level IV (well-designed case-control and cohort studies), whereas the remaining 13 articles were largely descriptive and thus provided weaker evidence at Level VI (a single descriptive or qualitative study). Despite their relatively low level of evidence, all 14 articles were included in this review due to the paucity of research in this area. Each of the articles examined at least three

Table. Investigations of Potential Risk Factors for Falls During Inpatient Rehabilitation Among Male and Female Stroke Survivors

Authors, year Level of evidence[a]	*N;* Mean years of age (*SD*)	Potential risk factors[b]	Limitations and comments
Czernuszenko & Czlonkowska, 2009 VI	1,155; 61.5 (14.3)	Age, length of stay, onset to admission, hemiparesis, hemineglect, medications, admission functional ability, aphasia, stroke type, sensory deficit, visual deficit	Possible noncomparability to U.S. stroke rehabilitation patients (onset to admission median 36.5 days) Unclear operationalization of stroke deficits (paresis, aphasia, hemineglect)
Rabadi et al., 2008 VI	754; 70 (13)	Age, gender, lesion type and location, cognition, motor or sensory impairment, visual field impairment, homonymous hemianopsia, hemineglect, balance, admission functional ability	No differentiation made between visual field cuts and neglect "Aggressive fall prevention program" not controlled for in analysis Unknown whether fallers and nonfallers differed by stroke type or location
Olsson et al., 2005 VI	158; 76.4 (8.6)	Male gender, ADL performance, urinary continence, postural stability, motor impairment, bilateral cortical or white matter lesions, use of diuretics, antidepressants, or sedatives	Replicated Nyberg & Gustafson (1997) study with sample that had greater ADL dependence and cognitive impairment Excluded "bedbound" patients Variables not operationalized using objective measures Definition of fall inconsistent with other studies
Smith et al., 2005 VI	225; 78[c]	Fall risk, cognitive ability, disability/functional ability, visual neglect, mobility	Instrumentation involved rarely used tests Validity of author-modified measures is unclear Evaluated association between STRATIFY composite score and falls; did not evaluate individual items (ADL ability, mobility, etc.)
Suzuki et al., 2005 VI	256; 68.6 (11.5)	Age, gender, interval from stroke to admission, length of rehab stay, interval between stroke and fall, ADL performance	FIM administered 1 week after admission, not day of admission. FIM scores of fallers and nonfallers overlap, making clinical translation difficult
Zdobysz et al., 2005 VI	1,014[d]	Functional ability on admission (self-care, transfers, locomotion, communication, social cognition)	Excluded patients discharged back to an acute care facility Cut point not specified for transfer scores indicative of highest risk
Stapleton et al., 2001 VI	13; 60	Visual inattention/neglect, attention, balance	Underpowered to detect significant results Visual-perceptual problems and attention deficits not differentiated
Teasell et al., 2002 VI	238; 72.7 (10.1)	Postural control/balance, functional ability, hemiplegia, stroke impairments (apraxia, aphasia, hemineglect, hemianopsia)	Excluded "bedridden" patients and patients who died during rehab stay Unclear how "cognitive deficit" measured Stroke impairments measured subjectively Reliance on incident reports may have underestimated falls
Sze et al., 2001 VI	677[d]	Gender, age, previous stroke, comorbidities, cognition, ADL performance, urinary incontinence, dysphasia, visual impairment, hearing impairment, visual and sensory neglect; communication deficits	Exclusion of patients with Foley catheters on admission may have resulted in less functionally impaired sample Clinician rating used to measures language impairment, visual, and sensory neglect
Nyberg & Gustafson, 1997 VI	135; 74.8 (8.9)	Sensory impairment, visuospatial hemineglect, dyspraxia, dysphasia, lesion location, blood tests, ADL performance, cognitive ability, motor function on most impaired side, postural stability (sitting and standing), postural hypotension, medications	Recorded only falls that "came to the knowledge of the nursing staff" Excluded "bedbound" patients Measured independent variables subjectively
Nyberg & Gustafson, 1996 VI	135; 74.8 (8.9)	Fall risk, male gender, ADL performance, urinary continence, postural stability, motor impairment/hemiplegia, bilateral cortical or white matter lesions, medications	Excluded "bedbound" patients Authors note that other empirically supported risk factors (e.g., impulsive behavior) were not included in the current study, thus providing an incomplete picture of fall risk

Table. Continued

Authors, year Level of evidence[a]	*N;* Mean years of age (*SD*)	Potential risk factors[b]	Limitations and comments
Webster et al., 1995 IV	55[d]	Hemineglect, presence of rightward-orienting bias without evidence of neglect, lesion location	Predominantly male sample Study participation began ≥3 weeks after admission to inpatient rehab Clinical practices specific to fall prevention may have biased results
Rapport et al., 1993 VI	32; 62.31 (6.33)	General fall risk, medications, visuospatial ability, attention, hemispatial inattention, failure to inhibit searching behavior, impulsivity, general cognitive impairment	"Aggressive" fall prevention program on unit may have biased results Investigator-developed Bilateral Scanning Task not in common use and psychometric properties not reported
Mayo et al., 1990 VI	202[d]	Response time, age, gender, side of lesion, previous stroke, depression, visual hemineglect, self-care ability	Measures for several variables (e.g., hemineglect) differed from other studies in the field, e.g. hemineglect Subjective measure of depression

Note. ADL, activities of daily living. [a]Rated according to Melnyk and Fineout-Overholt (2005). [b]Fall occurrence is the outcome variable for all studies; additional dependent variables (e.g., time to first fall) examined in some studies have been excluded from this review. [c]Standard deviation for subject age not reported in article. [d]Total sample mean age not reported in article.

possible risk factors for falls after stroke, with the studies exploring a total of 28 unique factors. Inconsistent methods for measuring the occurrence of falls and lack of detail regarding statistical procedures precluded comparison of effect sizes.

Factors With Strongest Empirical Support

Balance impairment. Impaired balance, or an inability to maintain proper body position, is a common and often long-lasting consequence of stroke that affects at least twice as many stroke survivors as healthy age-matched controls (Harris, Eng, Marigold, Tokuno, & Louis, 2005; Nichols, 1997). It is the attribute most often associated with falls during post-stroke rehabilitation. Five studies examined impaired balance (Nyberg & Gustafson, 1997; Olsson, Lofgren, Gustafson, & Nyberg, 2005; Rabadi et al., 2008; Stapleton, Ashburn, & Stack, 2001; Teasell et al., 2002), and four found it to be significantly associated with falling. Using independent *t* test analyses, both Teasell's and Rabadi's groups found a significant difference in mean scores on the Berg Balance Scale (BBS) between those who fell and those who did not ($p = .009$ and $p < .001$, respectively). Similarly, using occurrence of a fall as the dependent variable, Olsson and colleagues found that impaired balance more than quadrupled the risk for falling (hazard ratio [HR] = 4.50, 95% confidence interval [CI] 1.1–18.7), and Nyberg & Gustafson (1997) noted similar results (odds ratio [OR] = 3.85, 95% *CI* 1.38–10.72). Although significance was found in both studies, the confidence intervals are wide and thus results must be viewed with caution. Stapleton and colleagues did not find a significant relationship between impaired balance and falls; however, this study was greatly underpowered ($N = 13$) to detect significant associations.

Hemineglect. Hemineglect, also referred to as hemi-inattention or visuoperceptual neglect, is a perceptual deficit evident when an individual fails to acknowledge half of his or her body or environment, usually due to cortical damage in the right parietal or subcortical association pathway structures (Halligan, Marshall, & Wade, 1990; Young, Young, & Tolbert, 2008). Hemineglect should not be confused with visual field deficits, which are sensory impairments caused by damage to the optic tract or the geniculostriate pathway (Halligan et al.; Young et al.).

Nine studies examined hemineglect (Czernuszenko & Czlonkowska, 2009; Mayo, Korner-Bitensky, & Kaizer, 1990; Nyberg & Gustafson, 1997; Olsson et al., 2005; Rabadi et al., 2008; Rapport et al., 1993; Stapleton et al., 2001; Teasell et al., 2002; Webster et al., 1995), and five found it to be significantly associated with falls. Using the Line Bisection Test (Schenkenberg, Bradford, & Ajax, 1980), three research teams (Czernuszenko & Czlonkowska; Nyberg & Gustafson, 1997; Olsson et al.) demonstrated that hemineglect increased the odds of falling during stroke rehabilitation by a factor of 2.1 (95% *CI* 1.4–2.9), 1.47 (95% *CI* 1.20–3.90), and 2.57 (95% *CI* 1.2–5.4), respectively. Nyberg and Gustafson (1997) also found that more fallers exhibited hemineglect than did nonfallers (64% vs. 36%; $\chi^2 = 10.3$, $p = .001$). Webster and colleagues (1995) found that patients showing either frank left-sided hemineglect, or even a preference for the right visual field, fell more often compared to either stroke patients without these visuoperceptual issues or nonstroke rehabilitation patients without neglect [$F(3,71) = 6.11$; $p < .001$]. The remaining four studies revealed no relationship between hemineglect and falls.

Self-Care deficit. Six studies identified various aspects of self-care deficit, or impairment in the ability to attend to one's daily needs, as significantly and positively associated with post-stroke falls (Czernuszenko & Czlonkowska, 2009; Mayo et al., 1990; Nyberg & Gustafson, 1997; Suzuki et al., 2005; Sze, Wong, Leung, & Woo, 2001; Zdobysz et al., 2005). Zdobysz and colleagues found a significant relationship between falls and transfer ability ($p < .001$), but not between falls and a more general conceptualization of self-care operationalized by summing the scores for 13 motor self-care items encompassing activities of daily living (ADLs), transfers, elimination, and locomotion on the Functional Independence Measure (FIM; Keith, Granger, Hamilton, & Sherwin, 1987). Other investigations revealed significant relationships between general measures of self-care, including total and motor FIM scores, the Barthel Index, the Katz Index, and the Sister Kenny Self-Care Evaluation (Czernuszenko & Czlonkowska; Mayo et al.; Nyberg & Gustafson, 1997; Suzuki et al.; Sze et al.). The odds of falling when self-care was impaired ranged from 2.59 (95% *CI* 1.24–5.42) to 8.9 (95% *CI* 4.8–16.4; Czernuszenko & Czlonkowska; Nyberg & Gustafson, 1997; Sze et al.), and mean ADL performance scores were significantly different between fallers and nonfallers, ranging in significance from $p < .001$ (Mayo et al.; Zdobysz et al.) to $p < .05$ (Suzuki et al.).

Factors With Equivocal Empirical Support

Cognitive impairment. Cognitive impairment is common after stroke (Pohjasvaara, Erkinjuntti, Vataja, & Kaste, 1997; Sachdev, Brodaty, Valenzuela, Lorentz, & Koschera, 2004), and patients with cognitive deficits may attempt actions beyond their capabilities, forgetting that their condition renders them unable to ambulate, transfer, or perform other self-care safely without assistance. Three studies demonstrated a positive association between post-stroke cognitive impairment and falls, with *p* levels ranging from.05 to.001 (Rabadi et al., 2008; Suzuki et al., 2005; Teasell et al., 2002), whereas four studies found no such relationship (Nyberg & Gustafson, 1997; Rapport et al., 1993; Smith, Forster, & Young, 2005; Sze et al., 2001). Impulsivity, a component of impairment in the executive function domain of cognition, received attention in only one study. Although Rapport et al. (1993) found no significant relationship between general cognitive ability and falls in their small sample ($N = 32$), they demonstrated that one measure of behavioral impulsivity (i.e., failure to inhibit looking at a monitor until presented with a defined cue) was moderately associated ($r = .48$, $p < .003$).

Hemiparesis-motor impairment. Three of six studies found significant differences in hemiparesis-motor impairment scores between fallers and nonfallers, including Rabadi et al. (2008), $p = .03$; Sze et al. (2001), $p = .029$ and Teasell et al. (2002), [Correction added after online publication 13-Oct-2010. The *p* value has been updated.] $p = .013–.016$. Czernuszenko & Czlonkowska (2009) found that hemiparesis increased the risk for falling by 40% ($OR = 1.4$, 95% *CI* 1.0–1.8), although this finding must be viewed with caution since the confidence interval included 1.0. The remaining studies (Olsson et al., 2005; Rapport et al., 1993) failed to find a significant association.

Factors With Weak or No Support

Several factors examined in the 14 investigations included in this review had little or no association with falls. For example, all five studies (Czernuszenko & Czlonkowska, 2009; Nyberg & Gustafson, 1996, 1997; Olsson et al., 2005; Rapport et al., 1993) investigating relationships between falls and medications such as opioid analgesics, antihypertensives, antiarrhythmics, laxatives, and diuretics revealed no statistical association, although Czernuszenko & Czlonkowska (2009) found that subjects taking antidepressant medications had slightly greater odds for falling ($OR = 1.3$, 95% *CI* 1.0–1.74), though the confidence interval includes 1.0. Nyberg & Gustafson (1997) found urinary incontinence to be significantly associated with falls ($OR = 4.05$, 95% *CI* 1.72–9.52), but two other research teams (Olsson et al., 2005; Sze et al., 2001) did not. Findings were likewise equivocal across studies for the relationship between falls and stroke type; homonymous hemianopsia, or visual field deficit; apraxia, or the inability to complete motor movements despite lack of a neuromuscular deficit; attention; and generalized visuoperceptual deficit (non-neglect).

Other factors with little or no support as indicators of fall risk during inpatient rehabilitation for stroke included age, gender, stroke location, communication ability, comorbidities such as heart disease and depression, mobility impairment, social cognition (i.e., the ability to perceive and understand social situations and successfully engage in interpersonal interactions; Beer & Ochsner, 2006), impaired visual or hearing acuity, history of falls, postural hypotension, gait impairment, and response time. The combination of impaired balance, hemineglect, and male gender was also found to be nonsignificant (Olsson et al., 2005).

Discussion

Our integrative review of the empirical literature pertaining to inpatient stroke rehabilitation points to numerous factors that may influence falls in this population and setting. The relatively sparse evidence in this area varies in its support for the role of selected demographic variables, current health status, medications, functional and sensory deficits, cognitive and perceptual impairments, and physical capabilities in the occurrence of falls. Support is strongest for balance impairment, hemineglect, and deficits in performing self-care activities, with equivocal results for cognitive impairment, hemiparesis, and motor impairment, and little evidence that many of the risk factors empirically linked to falls in the elderly pertain to our target population.

Variations in terminology, instrumentation, eligibility criteria, and site characteristics across the studies we reviewed warrant careful consideration. In some instances, consistent findings for potential risk factors resulted when the same or similar measures were used despite differences in variable labels. In other instances, risk may have been undetected or underestimated due to use of inadequately sensitive measures or lack of representativeness in the sample. Investigations of the role of balance impairment in falls illustrate this point. Though variable names for impaired balance differed (e.g., "postural stability" vs. "balance") among studies that evaluated this potential risk factor, all of these studies used the BBS or the balance subscale of the Brunnstrom-Fugl-Meyer Scale. The latter measure assesses sitting and standing balance in a variety of static positions (Nyberg & Gustafson, 1997), while the BBS assesses balance during sitting and standing activities that include reaching and bending over (Teasell et al., 2002). Because the BBS assesses both static and dynamic activities, it may provide more clinically meaningful information for planning therapeutic activities as well as permit better prediction of persons likely to fall in the acute rehabilitation setting.

A key limitation of three of the studies examining impaired balance (Nyberg & Gustafson, 1997; Olsson et al., 2005; Teasell et al., 2002) is that bedridden or immobile patients were excluded, even though stroke patients often sustain falls from bed. Indeed, "immobile" patients in acute rehabilitation would likely still be participating in therapeutic activities such as bed-to-chair and bed-to-toilet transfers, and these activities are often associated with falls (Campbell, Breisinger, & Meyers, 2006; Czernuszenko & Czlonkowska, 2009; Rabadi et al., 2008; Sze et al., 2001; Zdobysz et al., 2005). Similarly, Teasell et al. excluded patients who died during rehabilitation, which may have obscured important information, particularly if death resulted from a fall.

Methodologic weaknesses in instrumentation and sample size may have also contributed to nonsignificant findings in four of the nine studies focused on hemineglect. Two of these studies were underpowered to detect a significant relationship (Rapport et al., 1993; Stapleton et al., 2001), and a third study relied on clinician judgment rather than objective measurement to ascertain hemineglect (Teasell et al., 2002). The fourth study (Mayo et al., 1990) measured hemineglect as a composite of clinician ratings plus several tests including the Line Bisection Test, a letter cancellation task (Weinberg et al., 1977), or the Motor-Free Visual Perceptual Test (MVPT; Colarusso & Hammill, 1972), rather than a single validated test. Clinician ratings may be of questionable reliability and validity, and disagreement prevails regarding the most clinically valid objective test for assessing hemineglect. Letter cancellation tasks may be artificially simplistic and thus not a valid measure of visuospatial hemineglect. The MVPT, which tests general visual-perceptual ability, is likewise not suited for measuring this construct (Oswanski et al., 2007). Thus, it appears that the utility of hemineglect in assessing risk for falling may hinge on the instrument used to measure this construct.

Findings for self-care deficit may have been similarly influenced by the operational definition of "self-care" used in each study that examined this potential risk factor, which was variously measured using the FIM, the Barthel Index, the Katz Index, or the Sister Kenny Self-Care Evaluation. Further, sample selection bias may have been introduced when patients rehospitalized during their rehabilitation stay were excluded from some of these retrospective studies. An estimated 10% to 20% of stroke rehabilitation inpatients require rehospitalization, and these individuals tend to exhibit lower self-care abilities than their nonrehospitalized counterparts (Ottenbacher et al., 2001). We surmise that studies excluding less capable stroke patients likely had decreased variability in self-care across samples and similarly underestimated the contribution of deficits in self-care to falls. Thus, the true relationship between self-care and falls may be even more pronounced.

Lack of consistent definitions of hemiparesis and motor impairment, with no clearly accepted measurement of these constructs, may have contributed to the mixed results for these potential risk factors. Heterogeneity or lack of sensitivity among cognitive measures may likewise have figured into the equivocal support demonstrated across studies for cognitive impairment. For example, several investigators used global cognitive screening or dementia screening tests such as the Abbreviated Mental Test (Smith et al., 2005; Sze et al., 2001) or the Folstein Mini-Mental State Examination (Nyberg & Gustafson, 1997; Rabadi et al., 2008). Other researchers relied on the cognitive FIM score (Suzuki et al., 2005; Teasell et al., 2002), whereas Rapport and colleagues (1993) used nurses' ratings to assess a variety of cognitive abilities including general cognitive ability, attention, impulsivity, and ability to perform a similarities task requiring abstract thought. While many of these measures are used clinically to assess dimensions of cognition, the method used by these investigators to measure impulsivity is not, which limits the applicability of their findings.

Many of the potential risk factors for which our integrative review revealed little or no empirical support have not been well studied, often having been examined in only one or two investigations. Findings for broadly defined factors such as “medications” or “comorbidities” may also have been inconsistent across studies due to variation in their operational definitions. In addition, several studies excluded patients with severe aphasia, which likely decreased the heterogeneity of the sample and limited the inferences that could be made regarding the role of impaired communication in falls. It is noteworthy that in the literature regarding community-dwelling older adults, several of these factors (e.g., medications, visual problems, and urinary incontinence) are accepted risk factors for falls (Rubenstein & Josephson, 2006; Tinetti, Speechley, & Ginter, 1988); however, in the stroke rehabilitation population these factors do not appear to identify potential fallers.

No association between post-stroke cognition and falls was found in studies conducted at sites with already existing aggressive fall prevention programs, which may have confounded the results due to heightened staff vigilance and use of fall prevention measures for all cognitively impaired patients (Rapport et al., 1993; Sze et al., 2001). Even at sites without such aggressive programs, the research project alone may have prompted increased staff vigilance and prevention efforts, thereby decreasing falls among cognitively impaired stroke patients (Smith et al., 2005).

Most of the research reports reviewed here employed a “shotgun” approach, investigating numerous potential correlates of falling, often without clear empirical or theoretical grounds for inclusion of the particular array of variables studied. Results of this review suggest that impaired balance, hemineglect, and ADL performance impairment are strongly associated with falls, and occur frequently in persons with stroke. Only two studies (Nyberg & Gustafson, 1997; Olsson et al., 2005) included all three of these risk factors, and only one study (Olsson et al.) considered how the combination of balance impairment, hemineglect, and male gender related to falls.

Our results indicate that future research is needed to explore the extent to which balance impairment, hemineglect, and self-care deficits together explain variability in the occurrence of falls among inpatients engaged in stroke rehabilitation. Likewise, multivariate methods should be employed to determine the amount of explained variance in falls when factors with mixed or moderate empirical support, such as selected medications, urinary incontinence, visual field deficits, apraxia, inattention, and general cognitive impairment, are included in the analysis. This would be consistent with the approach used by researchers who have identified risk factors for falls among older adults in both home and acute hospital environments (Ashburn et al., 2008; Byers, Arrington, & Finstuen, 1990; Lamb et al., 2003; Tinetti et al., 1988). Further, such an approach would enable refinement of fall prediction and development of tailored fall prevention programs in the rehabilitation setting.

More nuanced understanding of cognitive impairment in relation to falls during inpatient rehabilitation is needed, especially given the multiple cognitive domains that may be affected by stroke and the mixed results pertaining to post-stroke cognition found in this review. Tests of general cognitive ability used in most studies yielded mixed results, while executive dysfunction, the most common post-stroke cognitive impairment (Cavanagh, Hogan, Fairfax, Gordon, & Kopacz, 2002) affecting 50% of stroke survivors (Zinn, Bosworth, Hoenig, & Swartzwelder, 2007) was assessed in only one study, and then only with a measure of impulsivity, which was strongly associated with falls. Executive function entails higher-order cognitive processes that control, integrate, and organize other cognitive abilities. In contrast, executive dysfunction is manifested by disinhibition; impaired ability to think abstractly or synthesize information; verbal or motor perseveration; inability to shift from one task, behavior, or construct to another; and difficulty sequencing thoughts and actions (Leeds, Meara, Woods, & Hobson, 2001). Liu-Ambrose, Pang, and Eng (2007) have demonstrated that executive function is independently associated with both balance and mobility among community-dwelling stroke survivors. Further research is needed to elucidate the as yet unclear relationships between executive cognitive function and falls.

None of the studies we screened or reviewed specified a theoretical perspective or conceptual framework that guided the research. Identification of relevant theory explaining the multifactorial nature of falls among stroke rehabilitation inpatients is currently lacking. Formulation of a conceptual model of factors that contribute to falls during inpatient rehabilitation would help to guide future research and could also inform treatment strategies to prevent falls.

Developing a simple model for fall risk assessment that includes two or three predictors would particularly appeal to busy clinicians, and one such model has been trialed (Gilewski, Roberts, Hirata, & Riggs, 2007) on a mixed-diagnosis rehabilitation unit. After noting that 17% of the variability in falls on their unit was explained by mobility impairment and impaired problem solving, Gilewski and colleagues implemented fall prevention measures (primarily increased vigilance by staff) with individuals who exhibited these impairments. The result was a clinically desirable but not statistically significant reduction in the occurrence of falls, from 6.6 falls per 1,000 patient days to 5.7 falls per 1,000 patient days. Future research using a similarly parsimonious model that is informed by the results of this integrative review may account for a greater proportion of explained variance in falls among stroke rehabilitation inpatients.

Limitations

We confined this integrative review to published research, which may have resulted in a publication bias in our findings. Dissertations, unpublished research, and the grey literature including white papers and position statements were not accessed. Since studies reporting significant results are more likely to be published than those reporting nonsignificant findings (Melnyk & Fineout-Overholt, 2005), our findings may well present an incomplete picture. Insufficient statistical information presented in all the articles did not permit us to perform meta-analytic computations to establish an effect size across studies for each factor examined, which would have provided stronger evidence of the relationship between these factors and falls in the post-stroke rehabilitation population.

Another limitation of this review is the relatively low level of evidence represented by the investigations. The 14 studies were descriptive in nature, and only one study employed a stronger, case-control design, suggesting that this line of inquiry is in its infancy. Future research needs to involve stronger designs such as large case-control and comparison studies that permit computation of relative risk or odd ratios for each factor studied.

Design features made comparison across studies difficult or may have confounded the results. In addition to the aforementioned inconsistency among operational definitions for selected factors, it is noteworthy that the 14 studies were conducted internationally, representing Sweden, China, Japan, the United Kingdom, Canada, and the United States. Although such diversity is typically desirable, "inpatient rehabilitation" may differ sufficiently among these countries to limit the value of the cross-cultural comparisons. For example, in the United States, patients are often admitted to inpatient rehabilitation within 1 week of the stroke and stay 2 to 3 weeks. In the international studies, time from stroke to rehabilitation admission as well as rehabilitation length of stay varied widely. In some instances, patients started inpatient rehabilitation 3 months post-stroke or stayed up to 200 days, likely resulting in dissimilar samples on such key aspects as medical stability and functional ability. Exclusion of the most dependent rehabilitation patients, such as those who were rehospitalized, had severe aphasia, or required complete assistance with ADLs, also limited applicability of findings to all persons with stroke.

Conclusions

Rehabilitation professionals have long known that stroke survivors often sustain falls during their inpatient rehabilitation stay and that these falls may have catastrophic consequences. Preventing such falls is crucial, and identifying key risk factors for falls during post-stroke rehabilitation will ultimately enable clinicians to better target fall prevention efforts with patients and their families. This integrative review reveals the need for further research to better delineate the multifactorial nature of fall risk during inpatient stroke rehabilitation, with particular attention to the largely unexplored domains of cognition.

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Clinical Resources

- For assessment tools for a variety of health issues affecting older adults, http://consultgerirn.org/resources
- For a general fall prevention assessment, see http://consultgerirn.org/uploads/File/trythis/issue08.pdf
- Disussion of fall prevention for persons with stroke when they return to the community, http://americanheart.mediaroom.com/index.php?s=43&item=418

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