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Functional Reach, Depression Scores, and Number of Medications Are Associated With Number of Falls in People With Chronic Stroke

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Abstract

Background: Falls are a common adverse event among people with stroke. Previous studies investigating risk of falls after stroke have relied primarily on retrospective fall history ranging from 6-12 months recall, with inconsistent findings.

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Objectives: To identify factors and balance assessment tools that are associated with number of falls in individuals with chronic stroke.

Design: Secondary analysis of a randomized clinical trial.

Setting: Multisite academic and clinical institutions.

Participants: Data from 181 participants with stroke (age 60.67 ± 11.77 years, post stroke 4.51 ± 4.78 years) were included.

Methods: Study participants completed baseline testing and were prospectively asked about falls. A multivariate negative binomial regression was used to identify baseline predictive factors predicting falls: age, endurance (6 minute walk test), number of medications, motor control (Fugl-Meyer lower extremity score), depression (Patient Health Questionnaire-9), physical activity (number of steps per week), and cognition (Mini Mental Status Exam score). A second negative binomial regression analysis was used to identify baseline balance assessment scores predicting falls: gait velocity (comfortable 10 Meter Walk), Berg Balance Scale (BBS), Timed Up and Go (TUG), and Functional Reach Test (FRT). Receiver operating characteristic (ROC) and area under the curve (AUC) were used to determine the cutoff scores for significant predictors of recurrent falls.

Main Outcome Measurement: The number of falls during the 42-week follow-up period.

Results: Baseline measures that significantly predicted the number of falls included increased number of medications, higher depression scores, and decreased FRT. Cutoff scores for the number of medications were 8.5 with an AUC of 0.68. Depression scores differentiated recurrent fallers at a threshold of 2.5 scores with an AUC of 0.62. FRT differentiated recurrent fallers at a threshold of 18.15 cm with an AUC of 0.66.

Conclusions: Number of medications, depression scores, and decreased FRT distance at baseline were associated with increased number of falls. Increased medications might indicate multiple comorbidities or polypharmacy effect; increased depression scores may indicate psychological status; and decreased functional reach distance could indicate dynamic balance impairments.

Level of Evidence: II

Introduction

Falls are a common problem for people with stroke, and 37%–73% of these individuals suffer at least one fall annually [1–4]. Falls may lead to significant injuries, restricted mobility, depression, and increased fear of falling [1,5,6]. Because the consequences of falling are so high, it is paramount to create effective fall prevention strategies. Creating better prevention strategies depends on a good understanding of the factors that most strongly contribute to and predict falls [7]. Therefore, it is crucial to identify people who are at risk for falling so that these individuals can benefit from fall prevention interventions [8].

A few studies have investigated factors that contribute to falls in people with chronic stroke, but with somewhat inconsistent results [9–13]. These studies have indicated that contributing factors include motor impairments, history of previous falls, depression, longer time elapsed

after the stroke, and cognitive impairments. A previous study reported that Six-Minute Walk Test results, leg muscle strength, and physical activity level were not predictors of falls in people with chronic stroke [14]. Although some measures including the Six-Minute Walk Test, Fugl-Meyer Assessment, and number of steps might be correlated, these measures have different utility because they can measure different constructs such as endurance, motor control, and physical activity, respectively. Most previous studies have used long-term recall by participants. Given that the recall periods ranged from 6 months to 2 years, the accuracy and validity of these findings is of some concern.

Prior research has examined several balance and functional mobility measures to determine their ability to predict falls in people with chronic stroke, and these studies have generated conflicting results. Some previous studies reported that balance and mobility measures were not associated with falls in people with chronic stroke [14, 15], whereas others found significant associations between balance and/or mobility and falls in this population [11,13]. Pinto et al [13], in a cross-sectional study, showed that a longer Timed Up and Go (TUG) test result was a predictor of falling in individuals with chronic stroke. Other cross-sectional studies in persons with chronic stroke have reported that other tests (the Fall Efficacy Scale [FES] or the Berg Balance Scale [BBS]) differentiated people with multiple falls from those with one or no fall [11,15,16]. These conflicting findings might be attributed to study designs, fall definition as single or multiple falls, or a retrospective recall bias ranging from 6 to 12 months. Because of these conflicting results, there is a critical need to examine fall incidence with a design that better minimizes recall bias.

This study represents the secondary analysis of data resulting from a recent large, multi-site trial comparing the use of traditional ankle-foot orthotics (AFO) to foot drop stimulation orthotics in people with chronic stroke [17]. These data provide an opportunity to analyze falls prospectively over a 42-week period, during which time individuals were encouraged to increase their activity level through gait training provided by a physical therapist during clinic visits and a home exercise program [17]. The aim of this secondary analysis was to analyze the relative contribution of several possible factors to falls and to identify which baseline balance assessments were most accurate in predicting falls in these research participants. We hypothesized that people who fell would be of older age and have lower endurance, more weakness, lower cognitive functions, higher physical activity, more medications, and lower scores on balance/mobility assessment tools compared to people who did not fall. The results of this analysis will provide clinicians with important information about factors that predict falls and the most accurate balance assessment tools to identify fall risk in people with chronic stroke.

Methods

Study Design and Participants

This study is a secondary analysis of a previously published clinical trial [17,18]. In brief, this trial was conducted at 11 clinical sites and academic research institutions in the United States from May 2010 until February 2013. These sites included the University of Cincinnati, UC Health Drake Center; Weill Cornell Medical College; University of Kansas Medical Center; Long Beach Memorial Medical Center; University of Utah; Sharp

Rehabilitation Center; Brooks Rehabilitation Hospital; UT Southwestern Medical Center; National Rehab Hospital; and St Charles Hospital and Rehabilitation. Each site obtained approval from the Institutional Review Board, and all participants signed a written informed consent form. Each site recruited independently from clinical and community resources for their specific site.

This study included 197 community dwelling participants who were at least 3 months poststroke [17], were able to walk >10 m at a comfortable speed of 0.8 m/s without an orthotic device, with or without an assistive device, and were able to walk with a maximum of one person assisting. These participants also demonstrated a lack of active dorsiflexion during gait (“drop foot”) with available passive ankle range of motion past a neutral position. Exclusion criteria included: ankle plantar flexion contracture >5 degrees, pain in hemiplegic leg 4/10, botulinum toxin use to the hemiplegic side in the previous 6 weeks, absence of lower extremity sensation on the affected side, and concurrent participation in physical therapy or occupational therapy [17,18].

Participants were randomly assigned to 30 weeks of either foot drop stimulation orthotic (FDS) or standard ankle-foot orthotic (AFO), with 8 dose-matched physical therapy sessions during the first 6 weeks. The intervention included education on how to use the orthotic device, gait training, and individualized home exercise. After 30 weeks, the subjects in the AFO group crossed over into the FDS group, and the FDS group remained in their original group for an additional 12 weeks. As part of the study protocol, participants were specifically asked about falls during each study visit, and falls were documented during study visits. From week 0 to 6, the participants documented fall history 2 times a week. From week 7 to 42, the participants documented fall history every 4-6 weeks. Falls were defined as unintentionally lying down on the ground without loss of consciousness. Participants were permitted to keep the electrical stimulation orthotic device if they completed the entire study, and they were reimbursed for travel expenses for the visits that they completed. The results of this trial indicated that both groups (AFO and FDS) showed significant improvements in gait speed and other secondary outcomes (body structure and function, activity, and participation) within each group. However, there was no significant difference between the AFO and FDS groups in gait speed and other outcomes, except that user satisfaction was higher in the FDS group compared to the AFO group. The AFO group had a total of 61 falls and the FDS group had a total of 58 falls. There was no statistically significant difference in the number of falls between groups ($\chi^2 = 5.10$, $P = .64$). The mean number of falls for the AFO group was 0.67 and for the FDS group was 0.64.

Measures

The assessment of outcomes in the original clinical trial was carried out by licensed physical therapists who were blinded to group assignments, and each licensed physical therapist received onsite competency training and testing in each of the measures. Baseline results of the following potential contributing factors and balance/mobility assessment scores were analyzed.

Potential Predictive Factors

Potential predictive factors are as follows:

- Age of participants [19,20]: Older age has been shown to increase the risk of falling in people with stroke in an in-patient setting.
- Walking endurance using Six-Minute Walk Test (6MWT), with higher distance in meters indicating better endurance [21]: This is a reliable measure of functional walking endurance and has been shown to be associated with fall risk in people with acute stroke in an in-patient rehabilitation setting [22].
- Number of medications: This has been reported to increase the risk of fall in patients with acute stroke and older adults [23,24]. Previous research has shown inconsistent findings regarding increased number of medications and risk of falls in people with chronic stroke [11,12,25]. Thus, we included the number of medications in our analyses to examine this association.
- Motor control using Fugl-Meyer Assessment lower extremity score (FM): This score is a reliable measure for assessing and quantifying motor impairments for people with chronic stroke [26–28]. The maximum score for lower extremity is 34, indicating normal motor control, and lower scores indicate increasing levels of motor impairment. Because previous research has shown conflicting results about the association of FM and fall history [6,11], it is necessary to further evaluate this association in people with chronic stroke.
- Cognition using Mini Mental Status Examination (MMSE) score: This test is used to evaluate global cognitive function in older adults [29] and people with acute stroke [30]. A score below 24 indicates cognitive impairments that interfere with daily activities. The maximum score is 30, indicating normal cognitive function. Limited research has examined the association between cognitive impairments and risk of fall in people with chronic stroke, with conflicting results [10,15]. However, Harris et al [15] reported that MMSE score did not predict fall in people with chronic stroke.
- Depression symptoms were assessed using Patient Health Questionnaire–9 (PHQ 9): This is a self-reported questionnaire ranging from 0 to 27 with scores 5, 10, 15, and 20 indicating mild, moderate, moderately severe, and severe depression, respectively [31]. This is a reliable and valid measure in people with acute stroke [32]. Previous studies have shown the link between depression and falls in individuals with chronic stroke [12,33].
- Physical activity level was measured using a step activity monitor (StepWatch; Orthocare Innovations, Oklahoma City, OK) that was worn for 7 days at week 6 to quantify physical activity by counting the number of steps per week. It is a reliable and valid measure of physical activity in older adults [34]. More steps per day may increase the exposure to falls in people with chronic stroke. Although previous research used 6MWT and 10MWT scores [10] as measures for physical activity or average steps count with small sample size [35], 6MWT and 10MWT are not direct measures for physical activity. Using an objective

measure for physical activity is needed to better understand the association between physical activity and falls in people with chronic stroke.

Balance/Mobility Assessment

Balance/mobility assessment was based on the following:

- **Berg Balance Scale (BBS):** The BBS includes 14 items individually scored from zero (inability to perform task) to 4 (independent ability to perform task), and it has a maximum score of 56 that is generated by summing the scores of the 14 items. The BBS has been demonstrated to be a reliable and valid measure in elderly people as well as in people with acute stroke [36–38]. Higher scores indicate better balance. Limited research has yielded conflicting results about the ability of the BBS to predict falls in people with chronic stroke, although a score of 52 has been identified as a cutoff score for predicting falls in this population [11,16].
- **Timed Up and Go (TUG):** This measure of functional mobility is a reliable and valid measure for people with chronic stroke [39]. The baseline measures were analyzed for all participants with 2 trials for each, and the average time was calculated. Higher scores indicate lower functional mobility. Previous research has revealed conflicting results about the ability of TUG to differentiate between fallers and nonfallers in people with chronic stroke [11,13,16].
- **Functional Reach Test (FRT):** This measure assesses functional balance and limit of stability (in centimeters) during standing, and it is reliable and valid in elderly people and in people with acute stroke [40–42]. Each participant performed a total of 5 trials. The first 2 were practice trials, and the last 3 trials were averaged. For each trial, the participant was instructed to stand close to a wall without touching, and to position the arm that is close to the wall in a 90° angle of shoulder flexion and the hand with a closed fist. The assessor recorded the starting position of the third metacarpal bone on a large ruler. The participant was instructed: “Reach as far as you can forward without taking a step.” The location of the third metacarpal at the end of the reach was recorded. The difference between the starting and ending positions was measured in centimeters. Larger distance indicates better balance. Few studies have examined the utility of FRT in predicting falls in people with chronic stroke, but Tsang et al [16] reported that FRT has a limited utility for predicting fall in people with chronic stroke.
- **Gait velocity at a “comfortable pace” in 10 Meter Walk Test (10MWT):** This measure assesses gait speed in different populations, including people with chronic stroke. Testing was completed using a 14-meter course, with 2 meters at the beginning and the end to allow subjects to accelerate and decelerate during walking. This test is reliable [43] and valid [44] in people with chronic stroke. The participant selected whether to use an assistive device during testing. We averaged 2 comfortable speed trials at the baseline for this study. Hwang et al [10] showed that people with chronic stroke and a fall history have slower gait

speed compared to those without a fall history. However, others have reported that gait velocity did not predict falls in individuals with chronic stroke [15].

Data Processing

The original study data set was modified to include only the baseline factors of interest and fall incidence reports. Participants who left the study before week 12 were removed from the data set. Participants were classified as fallers if they reported one or more falls during the study, and as nonfallers if they reported no falls during the study period. The participants were further classified into nonfallers (no fall), single fallers (if they reported one fall), and recurrent fallers (if they reported 2 or more falls).

This study is a secondary analysis from a large clinical trial with the main outcome as the number of falls in people with chronic stroke (yes versus no). As a general rule of thumb, 10 participants are needed for each predictor variable included in the regression equation [45]. This study used 11 predictors (7 contributing factors and 4 balance mobility assessments). As such, our sample of 181 participants was consistent with the suggested sample size for a regression analysis of this nature.

Statistical Analyses

All statistical analyses were performed using IBM SPSS Statistics for Macintosh, Version 23.0 (IBM Corp, Armonk, NY). The significance level was set at .05 for all analyses. There was no difference in fall frequency between participants assigned to the different treatment groups (FDS and AFO) using a χ^2 test ($\chi^2 = 5.10$, $P = .64$). Therefore, these groups were combined for further analysis. We compared baseline characteristics between people who had one fall or 2 or more falls to nonfallers using one-way analysis of variance and the χ^2 test for continuous and categorical variables, respectively.

Two separate multivariate negative binomial regression analyses were performed to determine the effect of (1) contributing factors and (2) predictive balance assessment scores on the incidence rate ratio (IRR) of falls. These 2 analyses were performed separately to distinguish between factors that may contribute to number of falls from balance/mobility assessments that could be associated with number of falls. This method is useful to account for multiple falls for each participant.

To determine the cutoff scores for significant predictors of recurrent falls versus one fall or no fall, we used a receiver operating characteristic (ROC) curve. The area under the ROC curve indicates the overall accuracy of factors and balance assessment (eg, number of medications, depression, and FRT) in detecting the presence or absence of outcome (in this case, one or no fall versus 2 or more falls). For each ROC curve, the Youden index (sensitivity + [1 – specificity]) was calculated and largest Youden index was chosen to determine the cutoff score. Sensitivity and specificity were calculated indicating the true positive and true negative, respectively.

Results

Of 197 participants enrolled in the study, 10 did not have data from the 12-week follow-up and were removed from the analysis. Data from 6 other participants were removed from the analysis because of data entry error in one of the factors of interest. Data from the remaining 181 participants were included in the analysis (Figure 1). Participants with one or more documented falls during the study period were classified as “fallers” ($n = 74$), and participants who did not fall during the study were classified as “nonfallers” ($n = 107$). Figure 2 shows the distribution of number of falls and the frequency of falls in this sample. Also, fallers were subclassified into single fallers ($n = 50$) and recurrent fallers with 2 or more falls ($n = 24$). Recurrent fallers experienced a mean of 2.88 falls during the study (range 2-8 falls per participant). Table 1 shows the mean values for factors and balance scores in fallers with one fall, recurrent fallers, and nonfallers. Of the predictive factors, only 6MWT and PHQ-9 scores were significantly different between groups ($P = .03$ and $P = .03$, respectively). Of the predictive balance and mobility measures, only FRT in fallers was significantly different between groups ($P = .006$; Table 1).

Table 2 shows the results for predictive factors from the negative binomial regression analysis that includes 181 participants, as well as the incidence rate ratios (IRR) with 95% confidence intervals (95% CI). The number of falls was strongly associated with the number of medications (IRR = 1.09; 95% CI = 1.02-1.17) and depression (IRR = 1.11; 95% CI = 1.02-1.21), and these were the only significant predictive factors. This indicates that people taking more number of medications are 9% more likely to have more falls, and people with higher depression scores are 11% more likely to have more falls. Since 6MWT, FM, and number of steps may have overlap and correlation with each other, we performed separate analyses by including each one at time. We found that number of steps did not change our results. However, 6MWT and FM affected our results by obscuring one factor (number of medications). Number of medications was no longer a significant factor with 6MWT only (IRR = 1.02; 95% CI = 0.97-1.07), and with FM only (IRR = 1.02; 95% CI = 0.97-1.07).

Table 3 shows the results for predictive balance and mobility assessment measures from the negative binomial regression analysis that includes 181 participants and IRR with 95% CI. The number of falls was strongly associated with decreased FRT (IRR = 0.96; 95% CI = 0.93-0.99), indicating that people with decreased FRT are 4% more likely to have more falls.

We identified the cutoff scores for number of medications, depression, and FRT using the ROC curve. Our results revealed that number of medications differentiated recurrent fallers (people who had 2 or more falls) at a threshold number of medications of 8.5 (sensitivity 0.60; specificity 0.67), and an AUC of 0.68. Depression scores differentiated recurrent fallers at a threshold of 2.5 scores (sensitivity = 0.60; specificity = 0.65) with an AUC of 0.62. FRT differentiated recurrent fallers at a threshold of 18.15 cm (sensitivity 0.76; specificity 0.56) with an AUC of 0.66. Figures 3–5 and Table 4 summarize the ROC curve results.

Discussion

This study examined contributing factors and balance/mobility assessments that are associated with number of falls in people with chronic stroke over a 42-week period. We found that an increased number of medications and higher depression scores were the only contributing factors that were significantly associated with number of falls, whereas FRT was the only balance and mobility assessment that was significantly associated with number of falls. Our original hypotheses were partially supported because 2 contributing factors and one balance/mobility assessment were significant predictors. Other factors and balance/mobility assessments were not supported.

In this study, 41.8% of participants had at least one fall, and 13.26% of participants fell more than 2 times over the 42-week period. The fall rate in this study (41.8%) is higher than in several other studies of people with chronic stroke, which reported fall rates (fallers defined as having one or more fall) of 20 to 37% [9,13,16,46,47]. The multiple fall rate is consistent with that in a previous study of individuals with chronic stroke that reported approximately 12% of participants had multiple falls [48]. The definition of multiple falls helped to ensure that the classification of fallers was not due to a random chance but, rather, reflected a true fall risk [46,49].

Interestingly, the number of medications was one of the contributing factors that was significantly associated with the number of falls. In this study, every additional medication increased the risk of recurrent falls by 9% in people with chronic stroke. These results were consistent with a previous study that reported a significant association between high numbers of medications and multiple falls in people with chronic stroke [11]. A higher number of medications could reflect the direct or interactive effects of medication or could be the indirect result of multiple comorbidities. Certainly, many medications sedate central nervous system function, decrease blood glucose or blood pressure, and/or result in dizziness or decreased awareness that may increase the risk of falls [50,51]. Belgen et al [11] found a relationship between multiple falls and number of medications in persons with chronic stroke that was consistent with our findings. The results of this study corroborate other findings suggesting that polypharmacy may be an important factor to consider during fall risk screening in people with stroke. However, other studies reported that the number of medications was not associated with falls in people with stroke [33,52]. Further research is needed to explore the effect of type, frequency, and dosage of medications on falls in people with chronic stroke.

This study identified the cutoff scores for the number of medications that contribute to recurrent falls in people with chronic stroke. A cutoff score of 8.5 medications was associated with recurrent falls in this population, with the area under the ROC curve of 0.68 indicating that clinicians will predict recurrent falls 68% of the time. Although we identified cutoff scores for the number of medications that contribute to recurrent falls in people with chronic stroke, previous research has not shown relative cutoff scores in people with chronic stroke. A previous study reported that people who took greater numbers of medications had multiple falls compared to nonfallers and/or people with a single fall [11]. However, this

study did not provide a cutoff score for the number of medications that was associated with recurrent falls in people with chronic stroke.

Depression scores were associated with the number of falls in this study. Limited research has examined the association between depression scores and falls in people with chronic stroke. Our results were somewhat consistent with those of Hyndman et al, who reported higher depression and anxiety scores in people with multiple falls and chronic stroke compared to those with no or one fall [33]. However, another study did not find a significant difference in depression scores between fallers and nonfallers [48]. Previous studies did not examine the cutoff score of depression scores that was associated with falls. Our study identified the cutoff score of 2.5 for depression. This score was a predictor of recurrent falls in people with chronic stroke with 60% sensitivity and 65% specificity, as shown by the area under the ROC curve of 0.62 indicating that the clinicians will predict recurrent falls 62% of the time.

Out of the balance and mobility assessment measures included in this study, only FRT was significantly associated with number of falls. Each 1-cm increase in FRT distance decreases the risk of falls by approximately 4.1% in persons with chronic stroke. The FRT is a measure of functional balance determined simply by measuring the distance that an individual can reach anteriorly from a standing position. A decreased FRT indicates impaired dynamic balance and stability during functional activity such as reaching forward. However, FRT has been demonstrated to have a limited ability to predict falls in people with chronic stroke [16]. Extremely easy to administer, the FRT is feasible for use in nearly all clinical settings and is sensitive to change [53]. Smith et al [54] concluded that FRT was a quick, easy-to-use balance test and correlated with BBS in acute and subacute stroke. However, relatively little research has been conducted on the utility of FRT in people with chronic stroke. Tsang et al [16] found that FRT was able to distinguish fallers and nonfallers in people with chronic stroke, and history of fall compared to those without a history of fall. However, this study relied upon participants' 12-month recall of fall history. Our study appears to corroborate these findings through a prospective analysis of fall incidence.

This study determined the cutoff scores for FRT that predict multiple falls in individuals with chronic stroke. A cutoff score of 18.15 cm was identified with an area under the ROC curve of 0.66 indicating that clinicians will predict recurrent falls 66% of the time. These findings are inconsistent with previous research that identified different cutoff scores for FRT in people with chronic stroke [16]. A previous study identified a cutoff score of FRT at 24.1 cm that was associated with a fall history in people with chronic stroke [16]. Lack of research in the ability of FRT to predict falls may limit our knowledge.

Surprisingly, several well-known fall risk factors such as age, endurance, lower extremity motor function, cognition, depression, and physical activity level were not contributing factors to falls. These negative findings might be attributed to the characteristics of our sample. Our participants underwent a 6-week intervention including gait training, educational sessions on using ankle-foot orthotics and foot drop stimulation devices, and a home exercise program. This intervention might affect our results and the fall incidence in our sample. However, the contributing factors and balance/mobility measures were taken at

baseline before initiation of the intervention. In our study, the potential contributing factors of age, motor control, and cognition were not different between fallers and nonfallers.

Although the baseline BBS, gait speed, and TUG scores in this study did not predict falls, other studies have found that BBS score [7,8,16,23] and TUG score [7,13] did predict falls in people with stroke. In our findings, the mean baseline balance and mobility scores (BBS and TUG) were similar in fallers and nonfallers, and these measures were below the cutoff score for fall risk in people with chronic stroke, indicating a high risk of fall. These measures could not distinguish multiple fallers from single or nonfallers. Previous research has shown TUG as a predictor of falls in people with chronic stroke at 25 seconds cutoff scores [13], but our study did not find this relationship. The discrepancy in these negative results regarding BBS and TUG might reflect different fall definitions and more control on the recall bias than previous research. These study findings were consistent with some previous studies that showed BBS, TUG, and gait speed were not associated with falls in people with chronic stroke [15,55]. These mobility measures may need further research to establish their usefulness in predicting falls after stroke.

This study does have several limitations. First, it was a secondary analysis of a prospective dataset with a different study purpose. Because of this, the sample participated in interventional sessions including physical therapy exercise and balance training, in addition to use of an orthotic device. The group of recurrent fallers was also relatively small compared to that of nonfallers, which may have affected the statistical analyses. The generalizability of this study is another limitation because of the inclusion of a subpopulation of people with chronic stroke. Chronic stroke is often described as an interval of 6 months or more from onset. Although the majority of people included in the analysis met this definition of chronic stroke, there were a few participants ($n = 6$) with less than 6 months stroke duration. However, excluding these individuals from the analyses did not affect the results. Recalling fall incidence is one of the limitations because participants may have recall bias over 1 month. However, recalling a fall history over 1 month may have less impact on recall bias compared to 6 months or 1 year. The time effect was not a part of this analysis, and it may affect the results based on fall incidence and a change in the number of medications over the follow-up period. In this study, we did not evaluate the effect of type of medications on the risk of falls. FRT cannot be performed in a seated position, as this will limit the generalizability of the results for people who are not able to perform FRT in standing position. This study did not include a control group without stroke, and these factors and balance measures are not specific to people with chronic stroke. Finally, many other factors may contribute to and predict falls after stroke. Factors such as comorbidity, the side of and location of stroke, lesion type, medication type, and fear of falling were not included in the analysis.

Conclusion

The results of this study suggest that contributing factors to number of falls may include the number of medications and depression scores in people with chronic stroke. An increased number of medications might contribute to multiple falls due to the effect of polypharmacy and medication interactions. In addition, polypharmacy might reflect the presence of

multiple comorbidities that could be associated with the number of falls. In this analysis, we identified a useful cutoff score of 8.5 medications at the same time that may predict recurrent falls in individuals with chronic stroke. Depression scores may reflect a psychological aspect that could be associated with falls in people with chronic stroke. A useful cutoff score of 2.5 on PHQ-9 was associated with recurrent falls. Clinicians should consider including the number of medications and depression screening during fall risk assessment.

This study found that FRT was a significant balance assessment tool that was associated with the number of falls in persons with chronic stroke. FRT is an easy-to-administer balance test in clinical settings with a cutoff score of 18.15 cm for predicting recurrent falls in people with chronic stroke. Decreased distance reaching forward may increase the exposure to recurrent falls during standing, indicating poor balance in this population. Clinicians should consider using this easy-to-administer balance test during fall risk assessment.

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CME Question

Which clinical balance assessment is associated with recurrent fall risk in patients with chronic stroke?

- a.** Functional Reach Test (FRT).
- b.** Timed Up and Go (TUG).
- c.** Berg Balance Scale (BBS).
- d.** 10 Meter Walk Test (10MWT).

Answer online at me.aapmr.org

Figure 1.
Flow chart of participants included in this study.

Figure 2.
Distribution of fall among participants.

Figure 3.
Receiver operating characteristic (ROC) curve for number of medications.

Figure 4.
Receiver operating characteristic (ROC) curve for depression scores.

Figure 5.
Receiver operating characteristic (ROC) curve for Functional Reach Test (FRT).

Table 1

Baseline demographics and mean scores for factors and balance assessment tools

Variable	Recurrent Fallers (n = 24)	Fallers (n = 50)	Nonfallers (n = 107)	P Value
Age (y)	60.29 ± 14.17	61.66 ± 9.48	60.29 ± 12.22	.78
Gender females/total	6/24	22/50	41/107	.29
Stroke duration (y)	4.70 ± 3.97	4.90 ± 6.00	4.28 ± 4.32	.74
Assistive device: n				
None	3	11	34	
Single-point cane	10	18	36	
NBQC	4	11	25	
WBQC	4	5	3	
Hemi-walker	0	3	1	
Rolling walker	2	1	4	
Standard walker	1	0	0	
Others	0	1	4	
6MWT (m)	138.38 ± 70.03	180.00 ± 84.94	146.33 ± 81.38	.03
PHQ-9	3.79 ± 3.24	2.50 ± 2.65	2.17 ± 2.69	.03
Physical activity (steps count/wk)	2074.39 ± 1380	2094.55 ± 1208	2094 ± 1553	.99
FM	19.67 ± 4.17	21.26 ± 4.75	19.51 ± 4.84	.09
MMSE	27.75 ± 1.98	27.28 ± 3.06	27.09 ± 3.23	.63
Meds (number)	10.29 ± 4.69	7.74 ± 3.52	7.77 ± 7.04	.15
FRT (cm)	18.50 ± 7.44	24.70 ± 8.85	21.88 ± 7.48	.006
10MWT (m/s)	0.42 ± 0.21	0.48 ± 0.20	0.40 ± 0.20	.05
TUG (s)	29.63 ± 15.16	27.71 ± 23.53	34.31 ± 24.85	.23

Mean differences using one-way analysis of variance at .05 significance level. Recurrent fallers = people who had 2 or more falls; Fallers = people who had a single fall; nonfallers = people who did not fall; NBQC = narrow-base quad cane; WBQC = wide-base quad cane; 6MWT: Six Minute Walk Test for gait endurance; PQH-9: Patient Health Questionnaire-9 for depression; Steps = physical activity (number of steps per week); FM = motor control (Fugl-Meyer Assessment lower extremity score); MMSE = cognition (Mini Mental Status Examination score); Meds = number of medications; FRT = Functional Reach Test for dynamic balance; 10MWT: 10 Meter Walk Test for gait velocity (comfortable and fast 10 Meter Walk); TUG = Timed Up and Go for mobility measure; BBS = Berg Balance Scale for balance assessment.

Table 2

Negative binomial regression: Number of falls versus predictive risk factors

Variables	β	IRR (95% CI)	P Value
Age	0.01	1.01 (0.99-1.03)	.39
6MWT	0.001	1.01 (0.99-1.01)	.61
FM	0.001	1.01 (0.94-1.07)	.88
MMSE	0.02	1.02 (0.93-1.12)	.70
Meds	0.09	1.09 (1.02-1.17)	.01
Steps	0.00	1.00 (1.00-1.00)	.19
PHQ-9	0.11	1.11 (1.02-1.21)	.01

Negative binomial regression model for predictive risk factors at .05 significance level. 6MWT = Six-Minute Walk Test for gait endurance; FM = motor control (Fugl-Meyer Assessment lower extremity score); MMSE = cognition (Mini Mental Status Examination score); Meds = number of medications; Steps = Physical activity (number of steps per week); PHQ-9 = Patient Health Questionnaire–9 for depression.

Table 3

Negative binomial regression: Number of falls versus balance and mobility assessment tools

Variables	β	IRR (95% CI)	P Value
FRT	-0.041	0.96 (0.93-0.99)	.03
TUG	-0.019	0.98 (0.96-1.01)	.10
BBS	-0.018	0.98 (0.94-1.02)	.38
10MWT	0.38	1.46 (0.18-11.91)	.72

Negative binomial regression for predictive balance and mobility tools at .05 significance level. FRT = Functional Reach Test for dynamic balance; TUG = Timed Up and Go for mobility measure; BBS = Berg Balance Scale for balance assessment; 10MWT = 10 Meter Walk Test for gait velocity (comfortable and fast 10 Meter Walk).

Table 4

ROC curve for number of medications, depression scores (PHQ-9) and FRT

Variable	AUC (95% CI)
Number of medications	0.68 (0.56, 0.79)
PHQ-9	0.62 (0.50, 0.75)
FRT	0.66 (0.55, 0.77)

ROC = receiver operating characteristic curve; PHQ-9 = Patient Health Questionnaire–9 for depression; AUC = area under the curve; CI = confidence interval; FRT = Functional Reach Test.