STEADI Self-Report Measures Independently Predict Fall Risk

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Abstract
Falls are a significant contributor to disability and death among older adults. Despite practice guidelines to increase falls screening in healthcare settings, preventive care for falls continues to be infrequently delivered. Simplifying screening by relying on self-report of balance, gait, or strength concerns, alone may increase the frequency of falls screening. We assessed the diagnostic accuracy of self-report measures of gait, strength, and balance from the Centers for Disease Control and Prevention’s Stopping Elderly Accidents, Deaths, and Injuries (STEADI) for identification of fall risk. The criterion standard for fall risk was the Timed Up-and-Go (TUG). Assessments were conducted with 95 adults aged 65 years or older in an outpatient osteoporosis clinic between May 2015 and September 2016. Receiver operating characteristic curve analysis found that two self-report questions (“I feel unsteady with walking” and “I need my arms to stand from a chair”) had high discriminatory ability (AUC 0.906; 95% CI 0.870–0.942) to identify those at high fall risk; additional questions did not substantially improve discrimination. These findings suggest that two self-report questions identify those at risk of falling who would benefit from interventions (e.g., physical therapy). Performance testing as part of routine falls screening of older persons in the outpatient setting may be unnecessary.

Keywords
clinical geriatrics, falls, veterans, prevention

Background
Falls are the leading cause of fatal and nonfatal injury among adults aged 65 years and older (Hartholt et al., 2019). The adverse consequences of falls are substantial and include avoidable trauma care, loss of independence, and decreased quality of life (Florence et al., 2018). Approximately 10–19% of falls result in a major injury such as a fracture, soft tissue injury, or traumatic brain injury (Florence et al., 2018). Though women are more likely experience a fracture than men, men have higher associated mortality (Hartholt et al., 2019).

Certain physical characteristics, such as slow gait, lower extremity weakness, and balance deficits, are important predictors of those who will fall and sustain an injury (Ganz et al., 2007). Physical performance tests such as the Timed Up-and-Go (TUG), Thirty-second Sit-to-Stand (30s STS), and the Four-Stage Balance test (FSBT) have moderate to excellent sensitivity and specificity for identifying future fallers (Shumway-Cook et al., 2000). However, these tests can be impractical to perform in busy outpatient clinics and may be a reason for the lackluster adoption of falls screening in routine clinical practice (E. A. Phelan et al., 2016).

The Centers for Disease Control and Prevention (CDC) developed the Stopping Elderly Accidents, Deaths and Injuries (STEADI) initiative to increase falls’ screening and management (Stevens & Phelan, 2013). The STEADI

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algorithm, which is based on the American Geriatrics Society/British Geriatrics Society 2011 fall prevention guideline, recommends both self-report questions and performance tests (TUG, 30s STS, FSBT) to identify those at risk for falls and trigger interventions (e.g., physical therapy for fall prevention exercise training for those with gait, strength, or balance deficits) (Panel on Prevention of Falls in Older Persons, A.G.S., & British Geriatrics, S., 2011; Stevens, 2013). Despite the STEADI algorithm being a valid measure for predicting future fall risk, implementation has been variable (Lohman et al., 2017; Stevens et al., 2020). In one large-scale implementation effort, the TUG was completed in just over half (52%) of patients screened (Stevens et al., 2020). It is often impractical to assess physical performance in the context of primary care visits due to several barriers (e.g., limited time, space, and lack of personnel). In the context of remote (teledmedicine) visits, which are increasing proportions of outpatient visits since the COVID-19 pandemic, a simplified approach utilizing self-report may also be more feasible.

One way to overcome barriers to falls screening would be to rely on self-report measures alone to determine who would benefit from fall prevention interventions. Self-report (e.g., of instrumental and basic activities of daily living of functioning) is used to direct other aspects of health management with older adults and thus there is precedent for reliance on self-report. Thus, we assessed the diagnostic accuracy of STEADI falls screening questions for detecting fall risk among older adults in the outpatient setting.

**Methods and Materials**

**Setting**

The study setting was an outpatient osteoporosis clinic at the Veteran’s Affairs (VA) Seattle Division of the Puget Sound Healthcare System (VAPSHCS). The clinic serves mostly white male Veterans with an average age of 65 years, who reside primarily in the Puget Sound region (Ritchey et al., 2017). Veterans are referred to the clinic for evaluation and treatment of osteopenia or osteoporosis. A falls screening and management program based on STEADI principles was developed and implemented as part of usual clinic workflows beginning in 2015.

**Screening Procedures**

All persons presenting to the clinic for initial or follow-up care were offered falls screening if they met the following criteria: community-dwelling; able to complete pencil and paper form independently; no physical therapy for gait, balance, or fall-related issues in the past 6 months. Those who agreed to undergo screening completed a questionnaire and then were evaluated by a physical therapist (PT). The questionnaire included four falls screening questions (Table 1) from the 12-item STEADI “Stay Independent” fall risk self-assessment instrument (available at https://www.cdc.gov/steadipdf/STEADI-Brochure-StayIndependent-508.pdf) (Rubenstein et al., 2011). These four screening questions were chosen because they were hypothesized to have strong correlations with the STEADI physical performance tests. Three of these four questions are also the three “key” STEADI questions (Have you fallen in the past year? Do you feel unsteady when standing or walking? Do you worry about falling?), which can be used as an alternative to the full “Stay Independent” assessment. The questionnaire also assessed falls and injurious falls in the prior 12 months and assistive device use. The PT administered a cognitive screen (Mini-Cog©) and conducted four physical performance tests (TUG, 30s STS, FSBT, and 10-Meter Walk Test) (Stevens & Phelan, 2013).

Program purpose, methods, and evaluation were reviewed by the VAPSHCS IRB and determined to be a Quality Improvement/Quality Assurance project not requiring IRB review.

**Data Collection and Analysis**

Demographics, chronic conditions associated with aging that increase fall and/or fall injury risk, medications, responses (“yes/no”) to the screening questions, and physical performance test results were abstracted from the electronic health record and reported as percentage of the total screened.

The sensitivity and specificity of each self-report screening item was assessed against the criterion standard of physical performance test of gait, strength, and balance. Chi-square tests were performed to assess the association between a “yes” response on a self-report item and performance test results, with performance test results operationalized as being above versus below the standard cutoff for fall risk (i.e., greater than 12 seconds on the TUG; below expected number of repetitions for age and gender on the 30s STS; less than 10 seconds on the single leg stance [SLS] test of static balance) (Jones et al., 1999; Stevens & Phelan, 2013). The SLS is the most challenging of the four foot positions of the FSBT. It was used for this analysis due to its high clinical relevance for the osteoporosis clinic, in that impaired single leg balance has been found to predict injurious falls (Vellas et al., 1997).

Receiver Operating Characteristic (ROC) analyses assessed the utility of self-report items for predicting performance on the TUG. Area Under the Curve (AUC) values were calculated for a series of different combinations of self-report items with the highest specificity for TUG performance and compared to find the combination with the highest AUC. The TUG was used as the criterion standard since it is a sensitive and specific test for identifying community-dwelling older adults at risk for falling and is recommended by the CDC as well as the American and British Geriatrics Societies as a falls screening test (Panel on Prevention of Falls in Older Persons, A.G.S., &
Of the 294 patients seen in the clinic during the evaluation timeframe, 95 (32%) unique patients were aged 65 years or older, met other eligibility criteria for falls screening, and were screened for fall risk. These 95 patients comprise the sample for the analyses herein. Over 90% were able to complete each of the performance tests. As shown in Table 2, the mean age of the study sample was 77; most were male and white. Over one-third (39%) had fallen in the past 12 months, and 43% reported being afraid of falling. Over half answered affirmatively to feeling unsteady with walking, needing to use arms to stand from a chair or any combination of three, or more self-report screening questions. Nearly two-thirds were unable to hold an SLS for 10 seconds; the mean SLS time for the sample was 4.9 seconds. Forty-two percent performed below the fall risk cutoff for the TUG.

"Unsteady with walking," "need to use arms to stand from a chair," and afraid of falling had similar sensitivity and nearly the same specificity for predicting performance on the TUG as well as other performance tests (Table 2). The sensitivity of "a history of falling" was lower than the other three questions for the TUG and 30 sec STS. Sensitivity was generally higher for a self-report question and its corresponding performance test (e.g., "need arms to stand from chair" and 30 sec STS) (Table 2).

### Table 1. Characteristics and Falls Screening Assessments of the Study Sample (N = 95).

| Characteristic | Mean (Range, SD) |
|----------------|------------------|
| Age, years     | 77 (65–95, 7.4)  |
| Body Mass Index| 27.1 (17.3–46.8, 6.2) |
| Pain rating*   | 2.7 (0–12, 3)    |
| Number of falls in past 12 months | 0.7 (0–5, 3) |
| Characteristic, n (%) | | |
| Male           | 72 (75.8)        |
| White          | 75 (78.9)        |
| Mini-cog ≥3b   | 67 (70.5)        |
| History of vertebral fracture | 31 (32.6) |
| History of hip fracture | 8 (8.4) |
| Medical condition, n (%)c | | |
| History of cerebrovascular accident or transient ischemic attack | 16 (16.8) |
| Dementia       | 7 (7.4)          |
| Depression     | 33 (34.7)        |
| Osteoarthritis | 29 (30.5)        |
| Peripheral neuropathy | 14 (14.7) |
| Spinal degenerative disease | 23 (24.2) |
| Medication use, n (%) | | |
| ≥4 medications | 76 (80)          |
| Antidepressant | 27 (28.4)        |
| Antipsychotic  | 5 (5.3)          |
| Opioid         | 9 (9.5)          |
| Physical performance test, mean (range, SD) | | |
| Timed up-and-go, seconds (n = 95) | 13.9 (0–33.4, 6.3) |
| Thirty-second sit-to-stand, repetitions (n = 92) | 8.9 (0–26, 5.8) |
| Single leg stance, seconds (n = 95) | 4.9 (0–10, 4.5) |
| Self-report question, "yes" response, n (%) | | |
| "I have fallen in the past 12 months" | 37 (39) |
| "Sometimes I feel unsteady with walking" | 55 (58) |
| "I need to use my arms to stand from a chair" | 51 (54) |
| "I am worried about falling" | 41 (43) |
| 'Yes' to ≥3 items | 49 (52) |

* Pain ratings ranged from 0–10, with 10 being the highest value.

b Mini-cog scores range from 0–5, with score of greater than or equal to 3 indicating a lower likelihood of dementia.

c Medical conditions were extracted from the patient’s problem list found within the electronic medical record.

All analyses were carried out using IBM® SPSS® Statistics for Windows, Version 25.0 (IBM Corp, Armonk, NY). We did not perform any imputation for missing data.
ROC analysis revealed that two STEADI self-report items (“unsteady with walking” and “need to use arms to stand from a chair”) had high discriminatory ability for identifying fall risk, with the TUG used as the criterion standard (Table 3; Figure 1). Other 2-item question combinations had fairly comparable diagnostic accuracy and excellent discriminatory ability (i.e., 1.0 represents perfect discrimination). The AUC attenuated slightly with the addition of “history of falling” as a three-question combination (Table 3; Figure 1).

Discussion

This study found that STEADI self-report gait, strength, or balance questions, when grouped in two-question combinations, had high discriminatory power for identifying fall risk. Additional questions did not substantially improve prediction. These results suggest that providers in practice may rely on patient self-report to identify those at fall risk. This has important implications, as providers may use self-report alone to guide recommendations and referrals to evidence-based interventions as outlined by the STEADI algorithm (e.g., referral to PT for fall prevention exercise training).

Our review of the published literature revealed no other study assessing the screening characteristics of guideline-recommended falls screening (self-report) questions. While the guideline-recommended performance tests seem straightforward and fairly quick to administer, evidence suggests that barriers to conducting them may nonetheless limit screening (Phelan et al., 2016). Based on our experience within the context of clinical care delivery via telehealth, the administration of performance tests may not be feasible or safe. By contrast, a short set of self-administered screening questions may be more feasible and adaptable to a variety of virtual or non-virtual clinical settings (Rubenstein et al., 2011). Our ROC analysis, with an AUC in the excellent range for discrimination, suggests that two questions can reliably identify those at fall risk who need evidence-based interventions (Mandrekar, 2010). Our results are consistent with another study that found that using the three “key” (STEADI) questions compared to the full Stay Independent questionnaire decreased screening burden (Eckstrom et al., 2017). Of interest, we did not find that a history of falling was as useful for prediction of physical performance as other self-report questions. The most parsimonious approach to screening and assessment is critical in busy outpatient settings. Our study provides new guidance for healthcare providers on how to accomplish falls screening with their patients and identify who could benefit from fall prevention interventions (e.g., physical therapy).

Strengths of this study include concurrent collection of both self-report and performance measures of physical function and a high participation rate (90%) in falls screening compared to other studies using the STEADI algorithm (Stevens et al., 2020). A second notable strength is the inclusion of patients with cognitive impairment, which increases generalizability of findings. With our chi-square analysis, we were able to directly assess the association between perceptions of (walking and balance) ability with
actual ability, regardless of cognitive status. While recall bias around self-report of one’s personal history of falls may be worse among those with cognitive impairment, our findings suggest that reliance on falls history is not essential for screening purposes. Additional noteworthy study strength is the sample size, which was sufficient for the analyses conducted even in the context of a quality improvement program and convenience sample (based on 95% confidence intervals from ROC analyses) (Obuchowski, 2000; E. Phelan et al., 2010).

**Limitations**

Limitations include the under-representation of women and non-white individuals and the inconvenience nature of the sample. The proportion with a fall in the prior year (39%) is somewhat higher than in epidemiologic studies of annual fall incidence among adults aged 65 + living in the community and is likely due to the fact that ours was a clinic-based sample (Tinetti et al., 1995). It was also a sample that performed worse on measures of strength and balance compared to community-based samples, again likely because it was a clinic-based sample. While we did not formally evaluate for literacy, our prior study of screening implementation showed that over 90% of persons seen in the clinic could complete the self-report questionnaire independently (Ritchey et al., 2017). Replication of this study in other settings and with lower-risk populations will help to determine the generalizability of the findings herein.

**Conclusion**

This study suggests that two self-report questions may be sufficient to identify those at fall risk. Self-report represents a simplified, time-saving approach to falls screening that may increase screening rates—a critical first step in identifying who needs referral to evidence-based fall prevention interventions. Implementing fall risk reduction strategies with those at risk is essential to reducing the burden of falls and their associated injuries and healthcare costs. Self-reports of health and function with demonstrated utility will become increasingly important for

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### Table 3. Area Under the Curve for STEADI (Stopping Elderly Accidents, Deaths, and Injuries) Self-Report Falls Screening Question Combinations.

| STEADI Question Combinations | AUC  | 95% CI     |
|------------------------------|------|-----------|
| Question 1                  | 0.906| 0.870–0.942|
| Question 2                  | 0.891| 0.859–0.923|
| Question 3                  | 0.871| 0.838–0.920|

Note. AUC = Area under the curve; CI = Confidence interval; STEADI = Stopping elderly accidents, deaths, and injuries.

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**Figure 1.** STEADI (Stopping Elderly Accidents, Deaths, and Injuries) self-report question combinations receiver operating characteristic curve for fall risk. All three self-report questions (blue): Unsteady with walking; arms to stand (green); Arms to stand; history of fall (red); Unsteady with walking; history of fall (orange); Reference line (0.5 cut off; yellow).
guiding health care planning and decision-making in the telehealth era.

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Declaration of Conflicting Interests

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