Age and Ageing 2024; **53:** afae192
https://doi.org/10.1093/ageing/afae192

RESEARCH PAPER

Two simple modifications to the World Falls Guidelines algorithm improves its ability to stratify older people into low, intermediate and high fall risk groups

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Abstract

Background: We conducted a secondary analysis of a cohort study to examine the World Falls Guidelines algorithm's ability to stratify older people into sizable fall risk groups or whether minor modifications were necessary to achieve this.
Methods: Six hundred and ninety-three community-living people aged 70–90 years (52.4% women) were stratified into low, intermediate and high fall risk groups using the original algorithm and a modified algorithm applying broader Timed Up and Go test screening with a >10-s cut point (originally >15 s). Prospective fall rates and physical and neuropsychological performance among the three groups were compared.
Results: The original algorithm was not able to identify three sizable groups, i.e. only five participants (0.7%) were classified as intermediate risk. The modified algorithm classified 349 participants (50.3%) as low risk, 127 participants (18.3%) as intermediate risk and 217 participants (31.3%) as high risk. The sizable intermediate-risk group had physical and neuropsychological characteristics similar to the high-risk group, but a fall rate similar to the low-risk group. The high-risk group had a significantly higher rate of falls than both the low- [incidence rate ratio (IRR) = 2.52, 95% confidence interval (CI) = 1.99–3.20] and intermediate-risk groups (IRR = 2.19, 95% CI = 1.58–3.03).
Conclusion: A modified algorithm stratified older people into three sizable fall risk groups including an intermediate group who may be at risk of transitioning to high fall rates in the medium to long term. These simple modifications may assist in better triaging older people to appropriate and tailored fall prevention interventions.

Keywords: accidental falls; older people; aged; risk; guidelines

Key Points

- The original World Falls Guidelines algorithm could not identify community-dwelling older people with intermediate fall risk.
- Two simple modifications to this algorithm [applying broader Timed Up and Go (TUG) test screening and a shorter cut point (10 s) for the TUG test] could stratify the sample into three sizable and distinct fall risk groups.
- Application of this modified algorithm may assist in prescribing timely and appropriate tailored fall prevention interventions.

Introduction

Falls are an increasing problem globally, with one in three adults aged ≥65 years falling at least once a year [1]. The World Health Organisation has reported falls as the second leading cause of injury mortality [2] with an estimated 684 000 deaths in 2019, an increase of >50% since 2000 [2]. The burden of falls on health systems internationally is significant with an estimated 172 million falls annually resulting in disability, which is expected to increase as the world population ages [3]. Appropriate prescription of interventions is required to prevent falls in people at greatest risk of falling.

People rarely volunteer information about previous falls to primary health care physicians [4], who have limited consultation time (≤5 min for 50% of the world's population [5]) to identify those at risk of falling. To address this need, the World Guidelines for Falls Prevention and Management were compiled in 2022 through the consensus of 96 experts and the commissioning of systematic reviews of current evidence [6]. The Guidelines provided an algorithm for risk stratification, assessment and management/interventions for community-living older people. It categorises people into low, intermediate or high risk of falling groups for better resource allocation and timely and appropriate interventions.

The algorithm's entry point includes three key questions to determine whether further assessment is required and an assessment of mobility, either with a gait speed or Timed Up and Go (TUG) test. The questions are 'Have you fallen in the past 12 months?', 'Do you feel unsteady while standing or walking' and 'Do you worry about falling?'. However, these self-reported risk factors are insufficiently validated [7], subject to substantial under-reporting [8–13], and optimal mobility cut points for classifying older people at risk of falling are required. The algorithm's conservative cut points (<0.8 m/s for gait speed and >15 s to complete the TUG) may miss older people at increased risk of falls. For example, previous studies have suggested 1 m/s for gait speed [14], 12 s for TUG [15] and 10 s for fast walking speed [16].

Only one study to date has evaluated the Guidelines algorithm, and while successfully differentiating between those with a low and high risk of falls, categorised <1% of the sample as being of intermediate risk [17]. To support the algorithm's clinical use, further validation studies are required in representative samples of community-living older people.

This study conducted a secondary analysis of data from a large representative sample of community-living older people. Our primary objective was to determine whether the original algorithm could stratify the sample into three sizable, distinct fall risk groups or whether modifications relating to (i) broadening the mobility screening to minimise the reliance of self-reporting of fall risk factors and (ii) lowering the threshold for mobility impairment were necessary to achieve this. We compared fall rates and health, physical and neuropsychological performance, physical activity and quality of life across the derived risk groups using both the original and modified algorithms.

Methods

Participants

This study followed the STROBE reporting guideline [18] and comprises a secondary analysis of data for 693 participants aged 70–90 years recruited across two waves of a longitudinal study of cognitive function and ageing (Sydney Memory and Ageing Study) [19]. The Human Research Ethics Committee at the University of New South Wales granted approval for the study, and informed consent was obtained from individuals prior to participation.

Stratification of fall risk

Participants were stratified into either a low, intermediate or high risk of falling group using the original algorithm developed by Montero-Odasso *et al*. [6]. The entry point involved three key questions with the exact wording used in this study provided in Appendix Table S1. Participants who responded 'Yes' to any of these questions underwent the fall severity assessment and were classified as high risk of falls if they met one or more fall severity criteria, i.e. sustained an injury due to a fall, experienced multiple falls in the previous year, were unable to rise after a fall, fell due to a loss of consciousness/syncope or met the criteria for frailty (see Appendix Table S1). The remaining participants who did not meet one or more of the fall severity criteria were then classified as being at low or intermediate-risk based on a TUG cut point of >15 s. Finally, if participants responded 'No' to all three key questions, they were classified as low risk of falls.

In addition, a second modified algorithm was also evaluated. For this algorithm, (i) the TUG cut point was changed to >10 s, and (ii) all participants not classified as high risk of falls (i.e. without a positive fall severity factor) underwent a TUG test with slower participants classified as intermediate risk of falls. The >10-s cut point for the TUG test was based on the 'worse than average threshold' for individuals aged 70–79 years (>10.2 s) in a meta-analysis determining normative reference values for this test [16].

Demographic, health, physical, cognitive, physical activity and quality-of-life assessments

Participants completed a detailed medical history, listing major medical conditions and past falls. The type and number of prescribed medications, including psychotropic and cardiovascular medications, were recorded and categorised using the Monthly Index of Medical Specialities (MIMS) medications therapeutic index [20]. Supplements were not counted. Physical activity (hours per week) over the previous 3 months was assessed using the Incidental and Planned Exercise Questionnaire [21], and quality of life was assessed using the 12-item World Health Organisation Disability Assessment Schedule (WHODAS II) [22]. Mobility was assessed using the TUG [23], and physical performance was assessed with a test of hand grip strength and the Physiological Profile Assessment (PPA) [24]. The Mini-Mental State Examination (MMSE) was used as a global measure of cognitive function [25]. Cognitive motor speed and set switching were measured using the Trail Making Test (TMT) [26]. Concern about falling was assessed using the Falls Efficacy Scale International (FES-I) [27] and depressive symptoms were assessed with the 15-item Geriatric Depression Scale (GDS) [28]. These tests are described in further detail in the Appendix.

Falls surveillance

Falls were monitored prospectively for 12 months following baseline assessment with monthly calendars returned via reply paid envelopes. Participants were contacted by telephone within 2 weeks to obtain the falls information if calendars were not returned. A fall was defined as 'an unexpected event in which the person comes to rest on the ground, floor, or lower level' [29]. If loss to follow-up occurred (0.7%), participants were treated as if they had withdrawn at date of loss to follow-up.

Statistical analysis

To permit parametric analyses, data with right skewed distributions were square root or log transformed. Participants who were unable to complete an assessment were given a score of 3 SD above or below the mean to reflect poor performance. Missing data for 10 variables accounting for <8% of the data for any given variable (details provided in Table 1 legend) were found to be missing at random and imputed using expectation maximisation with 25 iterations [30]. A sensitivity analysis was also conducted using only complete cases. A one-way analysis of variance (ANOVA) and subsequent *post hoc* Tukey tests were performed to determine differences in continuous variables between the low, intermediate and high fall risk groups. Negative binomial regressions were used to compare the rate of falls, and Chi-square tests were used to contrast the prevalence of fallers and multiple fallers, gender and the presence of psychotropic and cardiovascular medications between groups. Statistical analyses were performed using SPSS (version 28 for Windows; SPSS Science, Chicago, IL). *P* values <.05 were considered statistically significant.

Results

Six hundred and ninety-three community-living older people (363 women) with a mean (SD) age of 78.7 (4.6) years comprised the study sample. The original algorithm (TUG > 15 s) classified 471 participants (68.0%) as low risk of falls, 5 participants (0.7%) as intermediate risk of falls and 217 participants (31.3%) as high risk of falls. The modified algorithm (TUG > 10 s) classified 349 participants (50.4%) as low risk of falls, 127 participants (18.3%) as intermediate risk of falls and 217 participants (31.3%) as high risk of falls (Fig. 1).

As the modified algorithm performed better in identifying three sizable fall risk groups, detailed fall risk factor and prospective fall rate comparisons are presented for the modified algorithm below and in the Appendix for the original algorithm.

Demographic, medical, physical and neuropsychological risk factors

For both the original and modified algorithms, ANOVAs revealed that the groups differed significantly with respect to age, cardiovascular medications, grip strength, balance, fall risk scores, mobility, processing speed, depressive symptoms, fear of falling and quality of life (Table 1, Appendix Table S2). *Post hoc* tests showed that for both algorithms, the high fall risk group was older, had worse physiological profile scores, grip strength and balance, poorer mobility (TUG test), slower processing speed, greater fear of falling and depressive symptoms, and reduced quality of life compared to the low-risk group. Additionally, in the modified algorithm, (i) the intermediate-risk group were significantly older than the low-risk group and (ii) the intermediate-risk group performed worse in assessments of general cognition and the above measures than the low-risk group.

The complete case sensitivity analysis revealed no changes in the relationships between the low-, intermediate- and high-risk groups for any variable with imputed data using both the modified and original algorithms—Supplementary Tables 4 and 5.

Broadening the TUG test screening to all participants without a fall severity factor and reducing the TUG test criterion to >10 s resulted in an additional 122 participants being classified as intermediate risk of falls. These participants, previously classified as low risk, were similar with respect to many physical and neuropsychological fall risk factors to the high-risk group, and significantly different to the remaining participants classified as low risk (Table 1).

Falls

As outlined in Table 2, the high-risk group had a significantly higher rate of falls than the low-risk group [incidence rate ratio (IRR) = 2.49, 95% confidence interval (CI) = 1.96–3.16] and the intermediate-risk group (IRR = 2.04, 95% CI = 1.47–2.84). There was no difference in the fall rate between the intermediate- and low-risk groups (IRR = 1.22, 95% CI = 0.86–1.73). The proportions of participants who experienced 1+ or 2+ falls in the follow-up year also differed significantly among the three groups—$\chi^2_{2, 696} = 47.67$, $P < .001$ and $\chi^2_{2, 696} = 32.89$, $P < .001$, respectively. *Post hoc* comparisons revealed that the high-risk group had a greater proportion of fallers and multiple fallers than both the low-risk and intermediate-risk groups (all $P < .05$) and that the proportions of fallers and multiple fallers in the

Table 1. Demographic, health, physical, neuropsychological, psychological and activity measures for the low, intermediate and high fall risk groups using the modified algorithm. Data are means (SD) unless otherwise stated.

	Low-risk group $N = 349$	Intermediate-risk group $N = 127$	High-risk group $N = 217$	Total sample $N = 693$	Group effect, P
Age, years	77.7 (4.3)	80.0 (5.1)*	79.3 (4.5)*	78.7 (4.6)	*<.001*
Female, *n* (%)	179 (51.3)	64 (50.4)	120 (55.3)	363 (52.4)	*.574*
Number of medical conditions[e,**]	2.0 (1.2)	2.1 (1.1)	2.2 (1.1)	2.1 (1.1)	*.149*
Medications[f]—total *n* (%)	4.8 (3.4)	5.6 (3.1)*	5.4 (3.3)	5.1 (3.3)	*.017*
Psychotropic medications[g], *n* (%)	57 (16.3)	23 (18.1)	49 (22.6)	129 (18.8)	*.149*
Cardiovascular medications[h], *n* (%)	82 (23.5)	25 (19.7)	67 (30.9)*,#	174 (25.4)	*.038*
TUG test time[i], s	8.1 (1.2)	12.5 (2.9)*	10.7 (3.7)*,#	9.7 (3.1)	*<.001*
TUG >10 s, *n* (%)	0 (0)	127 (100)*	104 (47.9)*,#	231 (33.3)	*<.001*
Grip strength[j], kg	29.0 (10.4)	25.4 (10.4)*	24.4 (11.2)*	26.9 (10.8)	*<.001*
Sway-foam[k], mm	173.3 (79.4)	216.6 (107.7)*	211.6 (101.4)*	193.3 (94.3)	*<.001*
PPA fall risk[l], score	0.67 (0.86)	1.24 (1.00)*	1.03 (0.97)*	0.89 (0.96)	*<.001*
MMSE[m], score[d]	28.5 (1.4)	28.0 (1.6)*	28.3 (1.4)	28.3 (1.5)	*.002*
TMT-A[n], s	42.6 (13.4)	48.7 (14.3)*	47.9 (15.8)*	45.4 (14.6)	*<.001*
TMT-B[o], s	110.5 (44.4)	131.4 (54.1)*	124.9 (55.9)*	118.9 (50.8)	*.001*
TMT-difference, s	67.9 (38.3)	82.7 (48.2)*	77.0 (48.9)	73.5 (44.1)	*.002*
FES-I, score[a]	20.4 (4.2)	23.6 (5.8)*	25.5 (8.2)*	22.6 (6.4)	*<.001*
GDS[p], score[c]	1.8 (1.7)	2.4 (1.9)*	2.8 (2.2)*	2.2 (2.0)	*<.001*
Physical activity[q], h/week	33.0 (15.9)	30.0 (15.5)	29.9 (16.5)	31.5 (16.1)	*.040*
WHODAS[r], score[b]	16.4 (5.2)	20.3 (5.7)*	20.5 (7.4)*	18.4 (6.4)	*<.001*

*Significantly different to the low-risk group $P < .05$ using *post hoc* Tukey tests. #Significant difference between the intermediate and high-risk groups, likely reflecting a TUG time >10 s being necessary for classification into the intermediate-risk group but not for the high-risk group. **Summed from the presence of heart disease, hypertension, diabetes, stroke, arthritis, osteoporosis and cancer history. [a]Falls Efficacy Scale International = 16 (no concern about falling) to 64 (severe concern about falling), [b]World Health Organisation Disability Assessment Schedule = 0 (no disability) to 100 (full disability), [c]Geriatric Depression Scale = 0 (normal) to 15 (severe depression), [d]Mini-Mental State Examination = 30 (normal) to 0 (<24 indicates possible cognitive impairment). Number of missing data points, [e]$n = 7$, [f]$n = 8$, [g]$n = 8$, [h]$n = 8$, [i]$n = 34$, [j]$n = 33$, [k]$n = 4$, [l]$n = 1$, [m]$n = 9$, [n]$n = 19$, [o]$n = 51$, [p]$n = 13$, [q]$n = 17$, [r]$n = 30$.

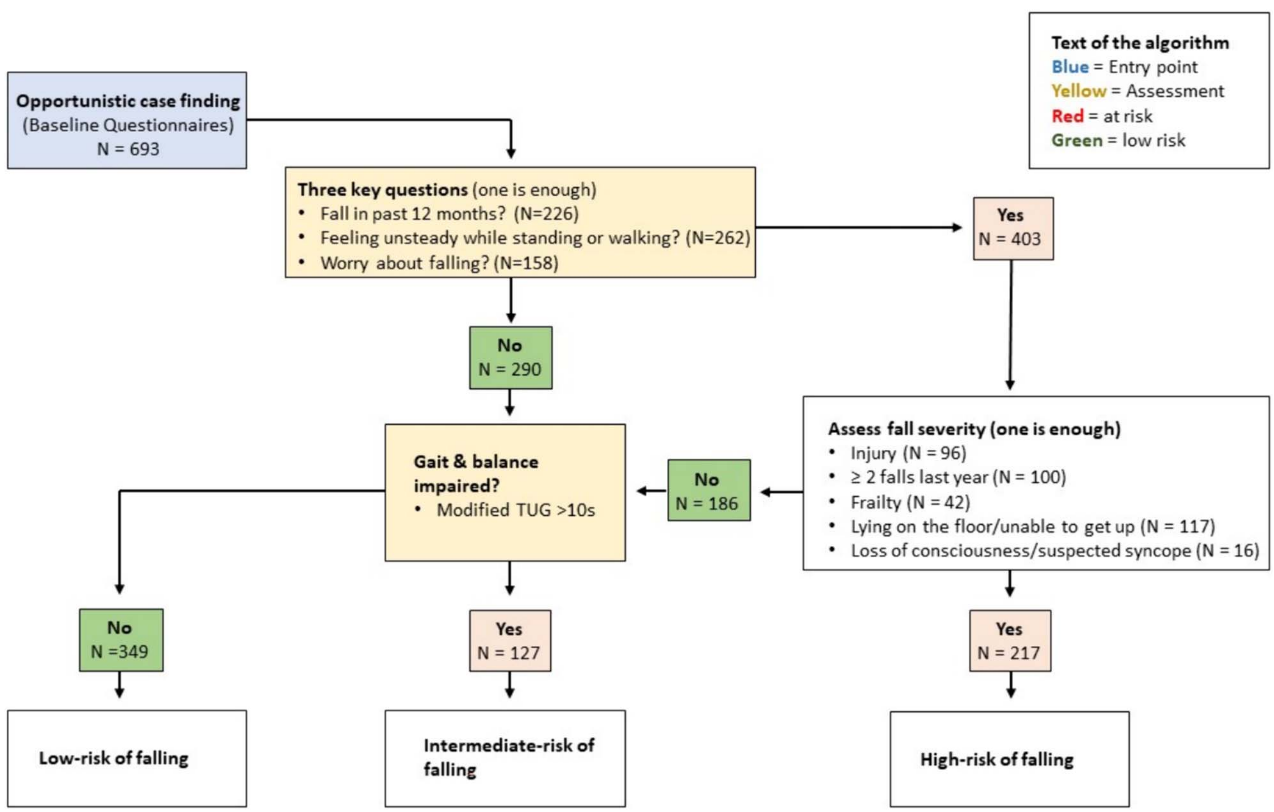

Figure 1. Number of participants at each step of the modified algorithm.

Table 2. 12-Month prospective fall characteristics of the low-, intermediate- and high-risk groups categorised using the modified algorithm.

	Number of falls	Mean fall rate per person/per year (SD)	Fallers, *n* (%)	Multiple fallers, *n* (%)
Low-risk group ($n = 349$)	196	0.57 (0.96)	125 (35.8)	47 (13.5)
Intermediate-risk group ($n = 127$)	87	0.69 (1.35)	41 (32.3)	19 (15.0)
High-risk group ($n = 217$)	305	1.41 (1.76)	137 (63.1)	71 (32.7)

low-risk and intermediate-risk groups were not statistically different—$P = .470$ and $P = .679$, respectively.

Discussion

This study examined the ability of the World Falls Guidelines fall risk algorithm to stratify a large sample of older community-living people into the three sizable and distinct fall risk groups. Consistent with findings from The Irish Longitudinal Study of Ageing study [17], the original algorithm was able to categorise older people into low- and high-risk groups, but failed to identify a sizable intermediate-risk group. In the current study, only five participants with negative responses to the fall severity criteria completed the TUG test in >15 s (0.7% of the sample). Two simple modifications to this algorithm were able to identify a sizable intermediate-risk group with physical and neuropsychological characteristics similar to the high-risk group, yet without the increased risk of prospective falls.

The first modification involved applying a cut point of >10 s for the TUG instead of the original >15 s. Previous meta-analyses have found high variability in TUG cut points, with suggested ranges from 8.1 to 16 s [31, 32]. We selected a TUG cut point of >10 s based on the 'worse than average threshold' for individuals aged 70–79 years (>10.2 s) reported in a meta-analysis [16]. The instructions used in this study, i.e. to complete the test as quickly but safely as possible, may help standardise the assessment procedure.

The second modification required all participants not classified as high risk of falls (i.e. without a positive fall severity factor) to undertake a TUG test with slower participants (>10 s) classified as intermediate risk of falls. This broader application of an objective mobility test accounts for potential under-reporting of the three key fall risk factors and the slow group being similar to the high-risk group in terms of physical and neuropsychological fall risk factors. This modified pathway would ensure that older people with impaired mobility are stratified into the intermediate-risk group at minimum and are recommended for referral to tailored exercise programmes.

Overall, the three fall risk groups differed with respect to many established independent risk factors for falls including age, cardiovascular medications, grip strength, balance, physiological fall risk scores, mobility, processing speed, depressive symptoms, fear of falling and quality of life. Most measures showed differences between the low-risk group and the intermediate- and/or high-risk groups. TUG time was the only factor that differed between the intermediate- and high-risk groups, with the intermediate-risk group taking significantly longer to complete the TUG test than the high-risk group. This difference is likely artificial due to TUG time >10 s being necessary for classification into the intermediate-risk group, but not the high-risk group. As the physical and neuropsychological profiles were similar between the intermediate- and high-risk groups, it is possible that the significantly higher fall rate in the high-risk group was due to other risk factors related to the five fall severity criteria.

The Guidelines algorithm was developed to allocate appropriate fall prevention interventions to each group [6]. Our findings support recommending multifactorial interventions for the high-risk group which had more than double the fall rate of the low-risk group and community-living older people [33]. The high-risk group could benefit from interventions directly addressing their identified risk factors, i.e. syncope and orthostatic hypotension, frailty, balance and mobility impairments, depressive symptoms and fear of falling. The similarity of the physical and neuropsychological profiles between the intermediate- and high-risk groups suggests that, in addition to targeted exercise or physiotherapist referral to improve balance and muscle strength as recommended in the Guidelines [6], a multifactorial fall risk intervention may also be required for many individuals in the intermediate-risk group. Many risk factors identified in both the intermediate- and high-risk groups are amenable to change through exercise including poor balance [34], muscle weakness [35], impaired mobility [34], cognitive impairment [36], depressive symptoms [37], fear of falling [38] and reduced quality of life [37]. Thus, balance and functional exercises warrant inclusion as a core intervention in all multifactorial intervention programmes.

The fall rate in the low-risk group (0.57 falls/year or 36% reporting one or more falls in the year following the assessment) was substantial and similar to many community-living cohorts assessed for falls [33, 39, 40] despite being labelled low risk. This is likely due to our participants being older [total sample, 78.7 (4.6) years; low-risk group, 77.7 (4.3) years] than the usual inclusion age of ≥60 years for fall prevention research [41], but is reflective of fall rates exhibited within this age range in previous research [39]. This fall rate indicates that the low-risk group may benefit from interventions comprising fall prevention education and exercise as recommended in the Guidelines [6]. There is recent evidence that women (65–73 years) who perform leisure time physical activity at the recommended level of 150 to 300 min per week have a reduced risk of experiencing non-injurious falls in the past year [42]. However, the highest quality evidence for effective fall prevention in the community remains for balance and functional exercises such that these programmes should be recommended to all older people [41, 43].

Strengths of this study included the availability of all the assessment domains outlined in the World Falls Guidelines algorithm for stratifying older people into fall risk categories, a large representative sample of community-living older people, prospective falls ascertainment following gold standard methods and a comprehensive assessment of medical, physical and neuropsychological performance measures. We did not administer a test of gait speed which is recommended as the primary mobility measure in the World Fall Guidelines [6]. Instead, we used the TUG test—the Guidelines' recommended alternative mobility test. While there is mixed evidence for the ability of the TUG test to discriminate between faller groups [6], it offers some advantages over a test of gait speed as it incorporates turning and sit-to-stand transfers and requires a smaller space to conduct the test (the recommended distance for steady state gait speed test being 10 m incorporating 2 m for both acceleration and deceleration). For such reasons, the TUG test remains the American Geriatrics Society's preferred mobility assessment tool when only one test is feasible [44]. Further research is required to determine whether a more stringent gait speed criterion such as 1 m/s [31] may also improve the original algorithm's ability to stratify older people into three fall risk groups.

Our findings have significant clinical implications. In addition to identifying low and high fall risk groups, the simple modifications of the fall risk algorithm identified a sizable intermediate-fall risk group with multiple fall risk factors but without a higher rate of falls than the low-risk group. The risk factors evident in this intermediate-risk group have previously been shown to be amenable to change meaning that targeted interventions may have success in preventing falls and a transition to frailty in this group. Importantly, these simple modifications maintain the quick and simple procedures for identifying those older people at increased fall risk.

Conclusion

This study examined the ability of the World Falls Guidelines fall risk algorithm to stratify a large representative sample of community-living older people into fall risk groups and verified these with prospective fall reports. The original algorithm categorised most older people into low- and high-risk groups and did not isolate an intermediate-risk group. Two simple modifications to this algorithm (applying broader TUG test screening and reducing the TUG test criterion for impaired mobility from 15 to 10 s) was able to identify a sizable intermediate-risk group that presented with physical and neuropsychological characteristics similar to the high-risk group possibly indicating a medium- to long-term increase in their rate of falls. These simple modifications may assist in better triaging older people at differing levels of fall risk to appropriate and tailored fall prevention interventions.

Supplementary Data: Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

Declaration of Conflicts of Interest: The Physiological Profile Assessment (NeuRA FallScreen) is commercially available through Neuroscience Research Australia. H.B. is or has been an advisory board member or consultant to Biogen, Eisai, Eli Lilly, Medicines Australia, Roche and Skin2Neuron. He is a Medical/Clinical Advisory Board member for Montefiore Homes and Cranbrook Care.

Declaration of Sources of Funding: This work was supported by a National Health and Medical Research Council L3 Investigator Grant [grant number 2002096] to S.R.L. and L1 Investigator Grant [grant number 1193766] to K.D.; an Australian Government Research Training Program Scholarship and Betty Fyfe Scholarship, NeuRA to C.H. and NHMRC programme grants ID350833 for the Sydney Memory and Ageing Study. Financial supporters had no role in the design, execution, analysis and interpretation of data, or writing of the study.

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Received 27 March 2024; editorial decision 22 July 2024