Development of a clinical multiple-lunge test to predict falls in older adults

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Abstract

Objective: To develop a new Multiple-Lunge test to distinguish between fallers and non-fallers in community-dwelling older adults. Design: The Multiple-Lunge test required the individual to lunge forward to a step length determined as 60% of their leg length, and return to start, for 5 consecutive repetitions. Inter and intra-day test-retest reliability of the Multiple-Lunge test was established across 2 testing occasions. A cross-sectional design was used to establish the sensitivity and specificity of the test to predict faller status based on retrospective self-reported fall history. Setting: Local retirement villages. Participants: 130 community-dwelling older adults, (mean age 77 ± 7 years) with (n = 40) and without (n = 90) a history of falls. Main outcome measures: Number of steps performed correctly, total time to complete 5 steps. Results: The Multiple-Lunge test was found to be reliable across trials (intra-day: ICC = 0.79-0.81 for steps; ICC = 0.86-0.88 for time. Inter-day: ICC = 0.77 for steps; ICC = 0.84 for time). Sensitivity and specificity values were calculated as 73% and 63% for predicting Multiple-fallers using the measure of all 5 steps done correctly. Conclusions: The test is easily administered and due to the challenging nature it may be well suited to detect subtle differences in abilities of higher functioning community-dwelling older adults. A practitioner can be confident in 7 out of 10 cases that an older adult who cannot complete all 5 steps of the Multiple-Lunge test is at high risk of falls. The results suggest that there is potential for the Multiple-Lunge test to be used in clinical practice, however, additional research on how to further increase its validity appears warranted.

Keywords: Aging, Accidental falls.

The number of older adults is increasing worldwide so an understanding of the potentially negative issues associated with ageing is essential. One of the most prevalent and often injurious consequences related to ageing is falls. The incidence of falls in people 65 years and older is 1 fall per year in approximately 30% of the population, with up to 30% of falls leading to serious injuries which hinder these individuals’ ability to function independently and contribute to an increased fear of falling, reduced quality of life and even death.

While falls are prevalent in older adults, there is considerable evidence that targeted approaches addressing specific falls risk factors may reduce falls rates in higher risk individuals or groups. Clinical tests are therefore often used in practice to identify those who are at a higher risk of falls, so that specific fall prevention programmes can be implemented for that individual or group of older adults. Examples of these tests include the Berg Balance Scale (BBS), Timed Up and Go (TUG), Functional Reach Test (FRT), Five Times Sit to Stand (5-STS) and the Fullerton Advanced Balance (FAB) scale. While most of these tests have been reported to have high-excellent test-retest reliability (ICC > 0.80) and high-very high sensitivity (> 80%) and specificity (> 80%) in predicting falls in frailer older
adults, 6-10 the ability of many of these tests to predict falls in more functioning, community-dwelling older adults may not be as strong.

For example, when used with community-dwelling elders, the BBS exhibits ceiling effects11-13 and has low sensitivity (25-45%) in predicting falls.12 Trueblood et al.14 examined the predictive ability of the TUG in assessing falls in community-dwelling elders and reported a sensitivity of 10% and specificity of 95%. Dite and colleagues15 reported that a score of 25 cm on the FRT gave the best combination of sensitivity (63%) and specificity (59%) in predicting falls status in community-dwelling elders. When assessing the predictive ability of the 5-STS in community-dwelling older adults, Tiedmann et al.16 also observed relatively low levels of sensitivity (66%) and specificity (55%). More recently, Hernandez et al.9 found that the FAB with a cut-off score of 25 out of 40 gave a sensitivity of 75% and a specificity of 53% in predicting falls in community-dwelling elders. The relative inability of most of these clinical tests to predict falls in well-functioning, community-dwelling elders therefore suggests that additional tests still need to be developed to assess falls risk in this population. Such tests would need to exhibit high reliability, validity and be relatively quick and easy to use by health professionals with minimal specific training.

As most falls involving older adults are characterized by a sudden loss of balance and an inability to quickly produce an appropriate corrective response,5 many studies have investigated how older adults respond to unexpected perturbations5, 17 and/or initiate stepping responses.18-20 These studies have shown that falls risk is associated with the use of more steps to regain balance after perturbation,21 decreased step length9, 18, 19 and longer response and transfer (step) times.20 This would suggest that stepping tasks in which the base of support continually changes position may be ideal tasks to assess older adults’ falls risk in clinical situations. As tripping is the most common cause of falls for older adults, accounting for up to 53% of all falls,5, 22 it would also appear useful to develop a stepping clinical test that assesses balance in a manner similar to that encountered when trying to arrest a trip-type fall. The movements required for trip recovery would appear to resemble a lunge type movement, with a relatively large, fast step in the forward direction and upon landing, the production of large forces required to counter the forward momentum of the centre of mass and to regain balance.5 While some lunge-type stepping tasks have been proposed to be useful falls risk assessment tools for older adults,18-20 they typically have been laboratory-based measures and involved only 1 anterior (out) or anterior-posterior (out and back) step. As such, these single step tasks may not be able to be used in clinical practice due to the inability to reliably and accurately measure parameters such as the duration of a step via a stopwatch.

The development and validation of a new, more challenging lunge-type stepping assessment tool for predicting falls risk in the increasingly active community-dwelling older adult population would therefore appear justified. The purpose of the following study was to determine the reliability and validity of 1 such test (the Multiple-Lunge test), which involves 5 consecutive anterior-posterior steps, in distinguishing fallers and non-fallers.

**Methods**

**Experimental design**

A cross-sectional sectional design was used to examine the ability of the Multiple-Lunge test to predict faller status in a group of community-dwelling older adults. Fall history was attained by
retrospective self-report by participants and constituted the criterion variable. The participants were
categorised as non-fallers (no falls), single-fallers (1 fall) or multiple-fallers (more than 1 fall) based
on their report of the falls they experienced in the previous 12 months. Two outcomes measures
from the Multiple-Lunge test were calculated and used as potential predictors of falls. They were
the: 1) number of steps done correctly; and 2) time taken to complete the test.

Participants

Participants were recruited for the study through several organisations. Various retirement villages
in the Auckland region were approached, and advertising was done at the villages by way of
newsletters, posters and/or presentations by the researcher. A number of community groups, such
as the New Zealand 60s Up Movement and Returned Services Associations were visited at meeting
times where the details of the study were presented by the researcher, and volunteers requested.
To establish eligibility for the study the Modified Physical Activity Readiness Questionnaire (PARQ)
was used to determine general level of ability to participate in the physical activity required for this
study whether the participants could safely perform the lunge tasks that comprised the
experimental procedures of this study. Normative cognition was determined by the participants’
ability to complete all forms and questionnaires with minimal or no assistance. Individuals had to be
65 years or older, independently living in the community, with normal vision or vision corrected by
eyewear. Individuals who had any self-reported neurological, musculoskeletal, sensory or cognitive
impairments that would affect their strength and balance, particularly of the lower extremity, were
excluded from the study. One individual was excluded due to being younger than the age criteria
and 1 was excluded due to very poor eyesight caused by glaucoma. All participants signed an
informed consent form. The study was approved by Auckland University of Technology Ethics
Committee (AUTEC). Participant characteristics are outlined in Table 1.
A total of 130 independent community-dwelling adults aged 65 years or older (mean age 77 ± 7 years; range 65 – 93 years) met the inclusion criteria. The distribution of participants by sex was 88 (68%) women and 42 (32%) men. The Falls History Questionnaire was administered to determine fallers from non-fallers. The questions included were those recommended by Lord et al.5 to establish a detailed history of the events surrounding a fall. A fall was defined as “an event resulting

<table>
<thead>
<tr>
<th></th>
<th>Non-fallers</th>
<th>Single-fallers</th>
<th>Multiple-fallers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (yr)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>76.7 ± 7</td>
<td>77.1 ± 7</td>
<td>77.3 ± 8</td>
</tr>
<tr>
<td>Range</td>
<td>65 – 91</td>
<td>65 – 93</td>
<td>67 – 89</td>
</tr>
<tr>
<td><strong>Height (m)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>1.62 ± 0.09</td>
<td>1.62 ± 0.07</td>
<td>1.65 ± 0.07</td>
</tr>
<tr>
<td>Range</td>
<td>1.47 – 1.89</td>
<td>1.52 – 1.76</td>
<td>1.55 – 1.78</td>
</tr>
<tr>
<td><strong>Mass (kg)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>72 ± 14</td>
<td>72 ± 9</td>
<td>79 ± 17</td>
</tr>
<tr>
<td>Range</td>
<td>35 – 119</td>
<td>56 – 94</td>
<td>62 – 119</td>
</tr>
<tr>
<td><strong>Leg length (cm)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>88 ± 5</td>
<td>88 ± 5</td>
<td>89 ± 3</td>
</tr>
<tr>
<td>Range</td>
<td>75 – 101</td>
<td>80 – 97</td>
<td>84 – 95</td>
</tr>
<tr>
<td><strong>Falls History</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>0</td>
<td>1</td>
<td>2.6 ± 0.8</td>
</tr>
<tr>
<td>Range</td>
<td>0</td>
<td>0</td>
<td>2 – 4</td>
</tr>
</tbody>
</table>

Fall history = number of falls reported within the last year
in an individual unintentionally coming to rest on the floor, or other lower level, not as the result of a major intrinsic event or overwhelming hazard.”23

Ninety participants (69% of sample) reported no falls in the last year. Of the 40 forty participants (31% of sample) reporting at least 1 fall in the previous 12 months, there were 25 single-fallers (19%) and 15 multiple-fallers (12%). These 40 fallers reported 64 falls in the previous year. Within the multiple-faller group, 9 participants reported 2 falls (60%), 3 participants reported 3 falls (20%) and 3 participants reported 4 falls (20%). The most common cause of a fall was a trip (61%), followed by turning (9%) and a slip (8%).

Fourteen individuals (mean age 79 ± 7 years) who participated in the full study also gave informed consent to complete a second testing session in order to gain some insight into the reliability of the Multiple-Lunge test measures. These 14 participants composed 43% (n = 6) fallers and 57% (n = 8) non-fallers. Of the 6 fallers, 2 (14%) were multiple-fallers (more than 1 fall in the previous year). The proportion of fallers in the sample was similar to the proportion generally reported in the literature for this age group2 and that of our overall sample of 130 participants. The second testing session was conducted 7 days after the initial session so to allow sufficient recovery from the first session and to control for weekly differences in activity.

**Physical activity**

The Rapid Assessment of Physical Activity Questionnaire (RAPA) was used to determine the amount of different types of physical activity (light, moderate, or vigorous) the participants engaged in during a normal week.24 Questions relating to strength and flexibility activities were also included. The questionnaire was scored to categorise each individual’s physical activity levels as either “Sedentary”, “Under-active” or “Active”. The RAPA has been found to have moderate to high sensitivity (81%) and specificity (69%) to predict activity participation in older adults.24

Participant physical activity categories by group are displayed in Table 2. There were no significant between-group differences in subject physical activity categories. Both the non-faller and faller group had a low percentage of sedentary participants (3.3% and 2.5% respectively). The majority of participants from all groups were scored a physical activity level of ‘under-active’.
Table 2: Subject physical activity categories by group

<table>
<thead>
<tr>
<th></th>
<th>Sedentary</th>
<th>Under-active</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Non-faller</td>
<td>3</td>
<td>3%</td>
<td>55</td>
</tr>
<tr>
<td>Faller</td>
<td>1</td>
<td>3%</td>
<td>29</td>
</tr>
<tr>
<td>Total participants</td>
<td>4</td>
<td></td>
<td>84</td>
</tr>
<tr>
<td>Single-faller</td>
<td>0</td>
<td>0%</td>
<td>20</td>
</tr>
<tr>
<td>Multiple-faller</td>
<td>1</td>
<td>7%</td>
<td>9</td>
</tr>
<tr>
<td>Total fallers</td>
<td>1</td>
<td>29%</td>
<td>10</td>
</tr>
</tbody>
</table>
Procedures

After completing the three questionnaires (PARQ, Falls History and RAPA), the participants were given a demonstration and explanation of the Multiple-Lunge test. The goal was to step forward with the dominant leg a predetermined distance and return to the starting position as quickly as possible for 5 repetitions. After considerable pilot testing, the required step distance was determined to be equal to 60% of leg length (as measured from the midpoint of the anterior superior iliac spine (ASIS) of the pelvis to the midpoint of the lateral malleolus of the ankle). The 60% of leg length distance was marked with tape on the floor so to make it clear what distance the participants were required to step. While the maximal return length of older adults is ~58% of their body height,19 Hsiao-Wecksler and Robinovitch18 suggested that a step equal in distance to 35% of standing height (quite similar to our 60% of leg length) may be optimal to regain balance. Our results during pilot testing also indicated that using step lengths >60% of leg length were perhaps too difficult to consistently achieve across 5 repetitions for many participants.

The instructions given to the participants before starting the Multiple-Lunge test were to start with the toes immediately behind the first line and step forward so that the heel of the stepping foot landed just past the second line (see Figure 1). Either leg could be chosen as the step leg. After the step foot landed the participants were to step back with the swing leg so that it was repositioned just behind the start line and next to the stance leg. They were told to attempt the lunge step in a single movement, without holding onto the tester or wall for support unless imperative to avoid a fall. A spotter was standing nearby to assist participants if they lost their balance. A stopwatch was used to determine the total time taken from the “go” command of the first repetition to the return to starting position after 5 repetitions. The participants performed a practice trial of between 2 to 3 steps followed by 2 timed trials, with 1 minute rest between trials.
Data Analysis

The outcome measures used in this study were the time to complete all 5 repetitions (total time) and the number of correct steps out of 5. Total time was calculated as the time from the initiation of the first step to the step foot being completely flat on the ground behind the start line after completing the fifth step. In order for each step to be classified as “Correct”, the older adult must have had received no assistance from the tester, walking aid, or by holding onto a wall, passed the
mark on the floor with the heel of the stepping foot and taken only 1 step to reach the starting and finish lines. The trial with the most correct steps was used for further analysis. If both trials for a participant had the same number of correct steps, the fastest trial was used for data analysis.

**Statistical Analysis**

Intraclass correlation coefficients (ICCs) were used to evaluate intra- and inter-day test-retest reliability of the Multiple-Lunge test. Analysis of all trials was done using the Reliability spreadsheet developed by Hopkins. ICC categories were based on standards recommended by Fliess where ICC values of 0.4 or below represent poor reliability, 0.5 to 0.6 represent moderate reliability, and values 0.75 and above represent good to excellent reliability.

In order to establish the accuracy of the Multiple-Lunge test in distinguishing between non-fallers and fallers, and thus the ability to predict falls in older adults, the sensitivity and specificity of the test was calculated. Sensitivity refers to the proportion of people who are fallers who test positive. If sensitivity is high, a negative test will rule out high fall risk. Specificity refers to the proportion of people who are not fallers who test negative. If specificity is high, a positive test will rule in high fall risk. Diagnostic test characteristics are defined and calculations shown in Table 3. These characteristics were determined using the truth table, adapted from Davidson displayed in Table 4.
Table 3: Definitions and calculations of test characteristics, adapted from Davison²⁷

<table>
<thead>
<tr>
<th>Test characteristic</th>
<th>Definition</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>The proportion of people who have the disorder who test positive</td>
<td>( \frac{a}{a+c} )</td>
</tr>
<tr>
<td>Specificity</td>
<td>The proportion of people who do not have the disorder who test negative</td>
<td>( \frac{d}{b+d} )</td>
</tr>
<tr>
<td>Positive Predictive</td>
<td>The proportion of people who test positive who have the disorder</td>
<td>( \frac{a}{a+b} )</td>
</tr>
<tr>
<td>Negative Predictive</td>
<td>The proportion of people who test negative who do not have the disorder</td>
<td>( \frac{d}{c+d} )</td>
</tr>
<tr>
<td>Accuracy</td>
<td>The proportion of people who were correctly identified as either having or not having a history of falls</td>
<td>( \frac{a+d}{a+b+c+d} )</td>
</tr>
<tr>
<td>Prevalence</td>
<td>The proportion of people in the sample who were fallers</td>
<td>( \frac{a+c}{a+b+c+d} )</td>
</tr>
</tbody>
</table>
Results

Good to excellent levels of intra-day reliability was reported for the number of steps correctly performed (ICC = 0.79-0.81) and total time (ICC = 0.86-0.88). Similar levels of inter-day reliability were observed for the number of steps correctly performed (ICC = 0.77) and total time (ICC = 0.84).
The number of steps performed correctly and total time to complete all 5 repetitions by each group is presented in Figures 2 and 3, respectively.

Figure 2: Percentage of non-failers, failers, single-failers and multiple-failers and the number of steps performed correctly from 5 steps during the Multiple-Lunge test.
Five out of 5 steps were performed correctly by 63% of the non-faller group and 48% of the faller group. This difference in completion rate of successful steps was greater when the faller group was divided into single and multiple-fallers with only 27% of the multiple-faller group able to correctly perform all 5 steps.
The ability of the test to distinguish between non-fallers and fallers (sensitivity and specificity, and predictive values) was determined by using the truth table format shown in Table 4. Comparison 1 evaluated the percentage of participants with 0 out of 5 steps correct, and involved comparisons of fallers to non-fallers, as well as multiple-fallers to non-fallers. Comparison 2 evaluated the percentage of participants with 5 out of 5 steps correct, using the same comparisons. The predictive properties of the Multiple-Lunge test were then calculated, and are presented in Table 5.
The highest specificity (87%) was achieved using comparison 1, 0 steps correct out of 5 steps. However, this comparison resulted in low sensitivity, 25% for fallers vs. non-fallers and 40% for multiple-fallers vs. non-fallers. Comparison 2, all 5 steps correct, resulted in moderate sensitivity and specificity, but these values were greater (sensitivity = 73%; specificity = 63%) when multiple-fallers and non-fallers were compared.
The highest positive predictor variable (75%) was for 0 correct steps (multiple-fallers vs. non-fallers), but the negative predictor (59%) was only moderate. The highest negative predictor (70%), with a positive predictor of 67%, was for 5 correct steps, multiple-fallers and non-fallers. Accuracy of the test was higher (0 correct steps = 63%; 5 correct steps = 68%) in the multiple-faller and non-faller comparisons, for both conditions, than the faller, non-faller comparisons (0 correct steps = 56%; 5 correct steps = 58%).

**Discussion**

The aim of the study was to develop a new step-based falls assessment tool (Multiple-Lunge test) for community-dwelling older adults and determine its reliability and validity in distinguishing between older fallers and non-fallers. Results would suggest that both of these aims were relatively well achieved, indicating some potential for the use of this test in clinical practice and/or research.

The intra-day test-retest reliability for the number of steps correctly performed (ICC = 0.79-0.81) and total time to complete all 5 steps (ICC = 0.86-0.88) of the Multiple-Lunge test were good to excellent. Although little research appears to have assessed the intra-day reliability of similar tests in community-dwelling older adults, the intra-day reliability of the Multiple Lunge test appears slightly lower than the FSST (ICC = 0.94-0.99). Similar to that recommended for the FSST, it would appear that the performance of 2 trials of the Multiple-Lunge test per testing occasion is sufficient to reliably determine performance. The inter-day test-retest reliability for the number of steps correctly performed (ICC = 0.77) and total time to complete all 5 steps (ICC = 0.84) were also good to excellent. Such inter-day reliability values appear within the range of values reported in the literature for similar tests involving community-dwelling elders. Specifically, the inter-day reliability of the Multiple-Lunge test appears substantially greater than that reported for the TUG (ICC = 0.56), quite similar to that of the 5-STS (ICC 0.82-0.89), but somewhat lower than that reported for the FSST (ICC = 0.93-0.98) and FAB (Spearman rank correlation coefficient = 0.96). These results suggest that the Multiple-Lunge test exhibits sufficient inter-day test-retest reliability to be a useful tool in evaluating the success of falls risk intervention programmes in this population.

Regardless of its reliability, the Multiple-Lunge test will not be commonly used in clinical practice or research if it is not a valid predictor of falls in older adults. Results of the present study indicated small to moderate differences between fallers and non-fallers in terms of Multiple-Lunge test performance. The comparison of mean total time to complete all 5 steps showed a significant difference between non-fallers (12.50 s) and fallers (15.4 s), and between the multiple- (16.79 s) than single-faller (14.57 s) groups. However comparisons of the results for mean total time is limited in that it does not take into account the number of steps completed correctly, for example an individual may have completed the test in a fast time at the sacrifice of performing all steps correctly.

When comparing the number of correct steps performed a high specificity (87%) but low sensitivity (25% for faller versus non-faller; and 40% for multiple-faller versus non-faller) was found for some out of 5 steps correct. Therefore, participants who are unable to complete any steps correctly are at increased risk of falls, but participants who perform at least 1 correct step cannot necessarily be classified as non-fallers. Another simple comparison involved the number of participants who could do all 5 steps correctly. Five out of 5 steps were done correctly by 63% of the non-faller group, 60%
of the single-fallers but only 27% of the multiple-fallers. This very basic analysis shows a difference in the abilities of multiple- but not single-fallers in relation to non-fallers on their ability to correctly perform all 5 steps. This comparison also resulted in the best combined predictive ability with a sensitivity of 73% and specificity of 63% for multiple-fallers and non-fallers. This implies that an individual who completed all 5 steps correctly had a 73% chance of not being a multiple-faller and that an individual who is unable to perform all 5 steps correctly has a 63% chance of being a multiple-faller. These results regarding the ability to perform all 5 steps correctly are therefore somewhat better than chance, but how well does this compare to the falls prediction literature for community-dwelling older adults?

The sensitivity of 73% and specificity of 63% for 5 correct steps as observed in the current study appears better in predicting falls in community-dwelling elders than many other common tests. Examples of this include the BBS (sensitivity 25-45%),12 TUG (sensitivity of 10% and specificity of 95%),14 FRT (sensitivity of 63% and specificity of 59%),15 S-STS (sensitivity = 62% and specificity = 55%),31 and perhaps the FAB (sensitivity of 75% and specificity of 53%). However, the Multiple-Lunge test did not have as high sensitivity (89%) and specificity (85%) as the FSST.15 As the predictive ability of the FSST in distinguishing fallers and non-fallers in community-dwelling older adults therefore appears much greater than that of other falls assessment tools, it is interesting to see what may account for this. Inspection of the participant demographics and falls definitions used by Dite et al.15 indicate some differences between their study compared to the current study and the literature for community-dwelling elders. Of the 81 participants in the study of Dite et al.15, all 27 of the multiple- and 27 single-fallers were currently a part of a Community Rehabilitation Program. Further, the definition used by Dite et al.15 for multiple- and single-fallers were 2 or more falls or 1 fall, respectively in the previous 6 months, rather than 12 months as used in the present study and much of the literature.16, 32, 33 The relative frailty of their multiple-faller groups was also demonstrated by the fact that they had very similar scores for the Step test, FRT and TUG to that of 300 older adults who were assessed 12-33 days after admission to an Emergency Ward after a fall-related injury. It is therefore likely that even though the participants in the study of Dite et al.15 were all community-dwelling, the fallers (especially the multiple-fallers) were frailer than what would be expected of other community-dwelling elders.

So while the reliability and validity of the Multiple-Lunge test both appear quite good, greater sensitivity and specificity might still be achieved with some modifications. For example, future studies assessing the psychometric properties of the Multiple-Lunge test may strive to recruit a greater proportion of multiple-fallers as recent studies are suggesting that single-fallers may not be truly representative of fallers, and that the definition of fallers should be more than 1 fall per year.9, 34 Additional studies should also examine the ability of the Multiple-Lunge test in predicting trip-related falls. This may be done by comparing trip-type fallers to non-trip-type fallers and/or non-fallers. Such studies may be a world-first as the authors are unaware of any other studies that have assessed the potential of any of the common falls risks tests to predict a certain type of fall. There was also a tendency of some of the more functioning participants to perform the Multiple-Lunge test at such a fast speed that they didn’t complete all 5 steps correctly. For example 3 individuals completed the Multiple-Lunge test in under 10 s but only performed 3 out of 5 steps correctly. Thus, some subtle changes in the instructions given to the older adults regarding the primary goal of the test might be appropriate and lead to improved predictive ability.
Study Limitations

The results of this study need to be viewed in light of some of the study limitations. One limitation was the relatively small number of multiple-fallers (n = 15) out of 130 total participants. The multiple-fallers comprised 38% of the faller group, which was slightly less than the ~50% that is commonly reported in the literature.35, 36 It is acknowledged that a larger number of multiple-fallers may have produced better results, but recruitment difficulties did not allow this. Such recruitment challenges are not unique, with other studies in this area obtaining a similar number (n = 16-20) of multiple-fallers11, 13 to that used in the current study. Furthermore, a similar study involving only 5 multiple-fallers has also recently been published.37

Secondly, the use of a retrospective research design while common in this area of research9, 11, 37 may have lead to some inaccuracies in the reporting of falls. Specifically, it is quite possible that this design may have lead to an underestimation of the true number of multiple-fallers, as recalling the number of falls sustained in the previous 12 months would require good memory. The use of a prospective design in which fall incidence is monitored over time may therefore have allowed a more accurate evaluation of the Multiple-Lunge test’s predictive properties.

Conclusions

The Multiple-Lunge test was found to have good-excellent intra- and inter-day test-retest reliability and to exhibit a good ability for identifying multiple-fallers, with a sensitivity of 73%, and specificity of 63% when using 5 out of 5 correct steps as the cut-off. When compared to the literature for healthy community-dwelling older adults, these reliability and validity results appear to be at least as good, if not better than that found for the BBS, TUG, FRT, 5-STS and FAB scale. It is therefore apparent that there is some potential for the Multiple-Lunge test to be used in falls risk assessments of older adults, especially those who are community-dwelling older adults due its challenging nature and lack of ceiling effects. However, certain modifications e.g. development of other cut-off scores, use of split times per step as well as step accuracy scores may improve validity, while providing more information on reaction time abilities. Assessment of the maximum number of correct lunges that can be performed within a certain time may also be useful.

References


