The Unilateral Forefoot Balance Test: Reliability and validity for measuring balance in late midlife women

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ABSTRACT
The objective of this study was to determine the reliability and validity of the ‘Unilateral Forefoot Balance Test’, a new high level balance test involving balancing on the forefoot, and to assess its ability to measure age based performance for women entering their sixties. Test-retest reliability was assessed with 28 healthy women aged 58-69. To determine concurrent validity, 195 women (mean age = 61.6 yr) were screened, and unimpaired women performed the Step Test, the Single Leg Stance test (with eyes open/closed, on firm or foam surface), and the Unilateral Forefoot Balance Test. The test-retest Intraclass Correlation Coefficient was 0.96, indicating high retest reliability. Of the currently used balance tests, the Single Leg Stance test with eyes closed gave the broadest distribution of results and its performance time correlated with the Unilateral Forefoot Balance Test (r = 0.63, p < 0.001), demonstrating the concurrent validity of the new test. Performance time for Unilateral Forefoot Balance Test was associated with age, with younger women performing better (median of 6.5 seconds for women 58-62 years old, p = 0.01), and older women having more difficulty. Age based normative data were constructed for subgroups of women (mean ages = 60 and 64). In conclusion, the ‘Unilateral Forefoot Balance Test’ test is reliable and valid in measuring high level balance in women up to their early 60’s. Clark MS (2007): The Unilateral Forefoot Balance Test: Reliability and validity for measuring balance in late midlife women. New Zealand Journal of Physiotherapy 35(3): 110-118.
Key words: Balance, women, aging, normative.

INTRODUCTION
Currently available balance tests have potential limitations in detecting subtle changes in balance associated with the early stages of aging, or due to injury. The limitations include ceiling effects or lack of sensitivity to detect mild differences. For example, the timed Single Leg Stance does not detect a significant decline in balance until the age range of sixty to seventy (Bohannon et al 1984), (Briggs et al 1989) whereas changes in balance may be occurring before this age. In addition, the Single Leg Stance test is not sensitive to subtle changes in balance in athletes with mild concussion (Riemann and Guskiewicz 2000). Table 1 describes various balance tests used in clinical practice. Disturbance in high level balance can be detected using equipment such as force platforms; however, this is not always practical in the clinical setting.

Maintenance of balance involves a combination of processes including sensory components to monitor position in space and the motor system to react and hold position. Any damage or degeneration of the visual, proprioceptive and vestibular systems (Shumway-Cook and Horak 1986), the neuromuscular components, or the connections between the systems through either brain injury, disease, or aging will result in a reduced ability to correct and maintain position. The Clinical Test of Sensory Integration and Balance (CTSIB) (Shumway-Cook and Horak 1986, Cohen et al 1993) assesses the integrity of the sensory components of balance control. The ‘Balance Error Scoring System’ (BESS) (Riemann and Guskiewicz 2000) incorporates the principles of the CTSIB, and examines stability in double, single and tandem stance, on either firm support, foam surface, with eyes open or closed, for at least 10 seconds. Being a very challenging test it is relevant for testing concussed athletes; however, it may not be applicable to function in older adults. Mobility scales are useful in describing function; however, they may not be adequate in identifying specific balance deficits.

It is understood that balance declines and the risk of falls increases with age (Briggs et al 1989, Low Choy et al 2003, Isles et al 2004), and decline may be exponential in the later decades (Low Choy et al 2003). Loss of balance associated with aging can be due to loss of skill necessary for maintaining equilibrium, or due to loss of practice. It can also be due to more global causes, such as atrophy of the brain due to reduced circulation (Smith and Sethi 1975, Riddle et al 2003), degenerative joint changes in the spine and lower limbs contributing to decreased position awareness (Wyke 1979), decreased reflexes, and muscle weakness contributing to decreased ability to react and hold positions (Nelson et al 1994, Lord and Clark 1996, Lord et al 2001, Robertson et al 2001, LaStayo et al 2003).

A test that is able to detect early changes in balance in post-menopausal women is important in terms of the early implementation of retraining
Table 1. Balance tests used in clinical practice.

<table>
<thead>
<tr>
<th>Test</th>
<th>Brief Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berg Balance Test</td>
<td>Rating of 14 functional tasks such as sit to stand, turning, lifting a foot onto a stool</td>
<td>(Berg et al 1989)).</td>
</tr>
<tr>
<td>Step Test</td>
<td>Speed of moving the non-supporting foot on and off a block</td>
<td>(Hill et al 1996)).</td>
</tr>
<tr>
<td>Timed up and Go</td>
<td>Getting up from a chair, walking around a point 3 metres away and returning to the chair</td>
<td>(Podsiadlo and Richardson 1991)).</td>
</tr>
<tr>
<td>The Functional Reach</td>
<td>Maximum reach forward in bilateral stance</td>
<td>(Duncan et al 1992)).</td>
</tr>
<tr>
<td>Sharpened Rombergs</td>
<td>Standing with one foot directly in front of the other</td>
<td>(Graybiel and Freigy 1966, Briggs et al 1989)).</td>
</tr>
<tr>
<td>Single Leg Stance</td>
<td>Standing on one foot with eyes open</td>
<td>(Bohannon et al 1984)).</td>
</tr>
<tr>
<td>Four Square Step Test</td>
<td>Stepping over cones in the form of a cross in the forward, sideways and reverse directions</td>
<td>(Dite and Temple 2002)).</td>
</tr>
<tr>
<td>The Clinical Test of Sensory</td>
<td>Examines stability in double stance on either firm support or foam surface, with eyes open, closed or visual conflict</td>
<td>Shumway-Cook and Horak 1986).</td>
</tr>
<tr>
<td>Interaction and Balance (CTSIB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance Error Scoring System (BESS)</td>
<td>Trials of stability in double, single and tandem stance, on either firm support, foam surface, with eyes either open or closed</td>
<td>Riemann and Guskiewicz 2000).</td>
</tr>
</tbody>
</table>

To prevent falls and osteoporotic fractures, postmenopausal women are particularly susceptible to fractures due to the loss of bone density associated with decline in hormone levels. A simple high level balance test that involves balancing on the forefoot was developed to address these needs. The Unilateral Forefoot Balance Test is based on the single leg stance test but uses a reduced base of support. The test is relevant to positions adopted in sports such as netball or in dancing. The test also has relevance to activities of daily life such as stepping on a rock or a narrow surface such as on a ladder, or reaching up to grasp something out of a high cupboard.

The purpose of this study was to assess the retest reliability of the test, and to determine its concurrent validity by examining the relationship of performance times of the test with other balance tests involving single leg standing. To this end currently used tests were assessed to determine the best standard with which to compare this new test. A secondary aim was to assess the test’s efficiency in the detection of mild balance loss in the early stage of aging in a group of women who were entering their sixties. In doing so, this study gave rise to normative data for the Unilateral Forefoot Balance Test, the Step Test and tests of single leg stance in various conditions, for women in the age group of 58-69.

METHODS
Test development

Prior to this investigation, a pilot study was conducted on 31 healthy volunteers (female = 16, male = 15, mean age 34.8 ± 13.8) who were recruited through the Faculty of Medicine and the Sports Union, The University of Melbourne. Inter-rater and re-test reliability were assessed as part of the pilot study. Participants were screened by the neurological physiotherapist for any neurological disorder, ear or vestibular problems, musculoskeletal injury to spine, upper or lower limbs or other problems which may affect ability to maintain balance. Preferred leg was determined by asking the participant which leg they believed was stronger and that they would kick a ball with. Dominance testing was also performed by gently pushing the participant from behind and observing which leg stepped forward but this did not correspond to preferred leg and was not used. Participants were first tested for their ability to hold single leg stance (flat foot) on their preferred leg for 30 seconds (ceiling effect). In the presence of two raters participants performed the ‘Unilateral Forefoot Balance Test’ (see test procedure below). Raters used standard stopwatches to time trials, and the best and the average performances were recorded and compared for reliability. Participants were retested one week later. For the purpose of this investigative pilot study, participants were also tested with eyes closed, however it was found that the eyes closed condition resulted in short performance times, for example less than 1-2 seconds that could not be timed reliably.

The overall mean best Unilateral Forefoot Balance time for the preferred support leg in this younger pilot study group (mean age 34.8 ± 13.8) was 20.4 ± 9.8 seconds (range 2.7 - 30.0). Therefore, using the criteria of one standard deviation as a cut off, young healthy adults could be expected to maintain the position for at least 10 seconds. There was no difference between left or right sides (p = 0.2). A sex difference was observed, with older females performing worse. Inter-rater reliability was found to be high with an Intraclass Correlation Coefficient (ICC) of 0.99, and ICC = 0.95 for re-test reliability.
Test procedure:
The test was performed with the subject standing in an open area with sufficient space to take a number of steps in all directions. Participants were asked to walk briskly or jog for 20 metres to warm up prior to the test and to remove footwear. The therapist provided a demonstration prior to testing.

The test requires the person to balance on the forefoot by placing the weight on the ball of the foot and lifting the heel just off the ground without raising it up high. The non-supporting leg must not be elevated beyond mid shin and it must not rest on the stance leg. Movement of arms is permitted. Timing commenced as soon as the person’s heel cleared the ground and stopped when the heel or the elevated foot touched the ground, or if the stance foot left the floor such as in hopping. If the heel touched the ground whilst the participant was first adopting the Unilateral Forefoot Balance Test position, the time was not included, and the participant was instructed to restart when the timer was ready, and the test recommenced. The order of testing was one trial for the preferred foot, and then one trial for the non-preferred foot, and this was repeated two more times or until 30 seconds was reached for the leg being tested (maximum of three trials). Times of less than 1.4 seconds were classified as inability to perform the test. Although the heel should not be pushed up high, the position however does require a strong contraction from the plantar flexors. Therefore if the participant was able to hold the position for greater than 10 seconds, they were given a rest of two minutes between trials to allow muscle recovery (Milner-Brown et al 1986).

Late midlife reliability and validity study: Subjects and Design
Participants were recruited through the Melbourne Women’s Midlife Health Project (MWMHP), a prospective longitudinal study which commenced in 1991 and has followed women through the menopausal transition and beyond (Dennerstein et al 1993, Burger et al 1995). Women were initially recruited aged 45-55 years by random telephone digit dialling in the Melbourne metropolitan area in 1991. Of the 2001 women who were interviewed, 779 women filled the entry criteria of having at least one ovary and not being on hormone therapy at that time, and 438 (56%) of these agreed to participate in the longitudinal study. Demographics such as age and education levels were recorded at baseline and women were contacted annually. In 2004, 247 women who were still actively enrolled in the project were invited to attend the centre for a large study involving cognitive function testing and balance testing. The cohort at the time of testing was aged 58-69 years. Fifty-two women were unable to attend for the following reasons: deceased (n=2), major health problems (n=12), working (n=5) or too busy (n=2), caring for family (n=8), family member died or unwell (n=4), distance to travel (n=8), not willing or no reason (n= 9), lost contact (n=2). A total of 195 women were available for the physical assessment. The study was conducted at the Office for Gender and Health, Royal Melbourne Hospital. Participants signed an informed consent, and The University of Melbourne Human Research Ethics Committee approved the study.

Re-test Reliability study
A sub-group of 28 women were recruited at an information session reporting on the results of the midlife study. Participants were screened for problems which may affect ability to balance as described in the pilot study. Height and weight were recorded. Participants were tested for their ability to hold single leg stance (flat foot) on each leg for up to 30 seconds. They then progressed to the Unilateral Forefoot Balance test as described above. Testing was repeated on an average of 4 days later (range 1 day to 1 week).

Validity Study
The order of tests (below) started with the easiest test, building up to the most difficult test. This procedure reflected clinical practice. Previous studies and the reliability study demonstrated no difference between the dominant and non-dominant sides (Bohannon et al 1984), therefore the right lower limb was tested first for each participant (both right and left legs were tested to confirm consistency of performance). Tests were done without footwear:

1. Step Test (Hill et al 1996): the number of times the foot was placed on and off a 7.5cm step as quickly as possible in 15 seconds.
2. Single Leg Stance Test in various conditions (hard surface eyes open/closed, then on foam eyes open/closed, visual conflict component not performed) based on the clinical test of sensory integration and balance/sensory organization test. (Shumway-Cook and Horak 1986) but in single leg stance rather than normal stance. The test was done 3 times or until the person reached 30 seconds for the lower limb being tested.
3. Tandem walk: a customized version whereby the person was instructed to walk ten steps heel to toe along a piece of tape fastened to the ground in their own time. The number of times the participant stepped off the line was recorded.
4. Unilateral Forefoot Balance Test (see above).

Statistical Analyses
For each test condition, data for trials for the left and right foot for each participant were available. The best and average individual performances were analysed. An intraclass correlation coefficient (ICC) was calculated to assess retest reliability. Change between test and retest scores were also examined by comparing time 1 score with time 2 score using a paired T-test.
For the validity study, distributions of test performances were investigated for normality, and the square root of scores was used for those tests that did not have a normal distribution. The balance test which demonstrated the most even spread of results (single leg stance with eyes closed) was selected as the gold standard to test the concurrent validity of Unilateral Forefoot Balance Test against. The Pearson’s Product moment correlation was calculated between the Unilateral Forefoot Balance Test and age and individual tests. Performance times were divided into older and younger subgroups according to whether the woman’s age was above or below the mean age of 62.0 years, and T-tests were used to determine age group differences. The percentage of women who could do the tandem walk without fallers was calculated. For the normative data medians, 5th percentiles and interquartiles were calculated to best represent the distribution of the performance times. Analyses were performed using SPSS.

RESULTS
Re-test Reliability
The ICC for test-retest reliability for the Unilateral Forefoot Balance Test was 0.96 with 95% CI of 0.93 to 0.98. The change in performance between test times was approximately one second which was not significant (p = 0.5). These results indicate the re-test reliability of the Unilateral Forefoot Balance Test is high.

Validity study sample characteristics
Women were screened for musculoskeletal or neurological problems as follows: musculoskeletal; past foot or ankle fracture or tendon damage (17), osteoarthritis of the knee or knee pain (13), osteoarthritis foot (4), rheumatoid arthritis (3), knee replacement (2), hip replacement (2), disc prolapse (1), calf disorder (2, one of which was a genetic disorder); ear damage or infection that has resulted in self reported vestibular damage (3); Neurological disorders (5, post-polio, Guillain Barre, stroke, ataxia associated with hypoxia at birth, ventricle/cerebro spinal fluid disorder); Psychotropic drugs (1). Thus of the original 195 women, 142 (72.8%) aged 61.6 ± 2.5 were tested for left lower limb stance and 133 (68.2%) for the right. Of the women tested, 11 were left footed, (94.4 % were right dominant). The women who were excluded from the balance testing due to physical problems were significantly older (p = 0.008).

Performance times on balance tests
There was no difference in testing between right and left support limbs on any of the tests (T-test, p > 0.05). The distribution of the performance times (best) in single leg stance in various conditions is shown in Figure 1. There was a ceiling effect for the tests of single stance on a firm surface (Fig.1A) and for single leg stance on foam (Fig. 1B). That is, 85% of women were able to maintain single leg stance for either support leg for 30 seconds, and 65% of women were able to maintain single leg stance on foam for 30 seconds. Performance times for single leg stance with eyes closed demonstrated a wide spread of results and was the most sensitive balance test in detection of range of ability (Fig. 1C), and was later used to determine the concurrent validity of the new test. The most difficult test, single leg stance on foam with eyes closed was much lower than the other tests, the median being 2.3 seconds and 20% of the women were unable to do the test (Fig. 1D).

The median performance time for the Unilateral Forefoot Balance Test for the cohort was 6 seconds, with 4 % unable to maintain the position.

We also examined the ability of women to perform tandem walk test (10 steps heel-toe on line). Of the women, 90.7% could perform the task. This test is therefore not appropriate for detecting differences in balance and it was not able to detect a difference in performance between the younger and older women.

Concurrent validity of the Unilateral Forefoot Balance Test
To determine the concurrent validity of the Unilateral Forefoot Balance Test, the single leg stance with eyes closed test was used for the analysis because it had the best distribution of performance times. The tests were found to be highly correlated (r = 0.63) confirming the concurrent validity of the Unilateral Balance Test (Table 2).

There was also a significant correlation between the new test and the other existing tests (Table 2), (the correlations may be lower than expected as some of the tests had ceiling effects). The lowest correlation with the new test was for the Step Test (p=0.28); however, this test differs from the other tests in the study in that it is a test of dynamic balance, as opposed to supporting oneself in various conditions on a single leg.

The ability of the Unilateral Forefoot Balance Test to measure high level balance
The ability of the Unilateral Forefoot Balance Test to further differentiate balance skill above that of standard tests was investigated by selecting women who attained the 30 second ceiling in single leg stance on foam with eyes open (n = 92), and examining their performance times for the Unilateral Forefoot Balance Test. That is, to determine if the new test would provide a spread of results, as opposed to a ceiling effect as with current tests. Figure 2 shows that there was a broad spread of times for the Unilateral Forefoot Balance Test for this group. The mean time for the Unilateral...
Forefoot Balance Test for these higher functioning women was 10.1 (± 8.1) which is well below the 30 second ceiling. These results demonstrate that the Unilateral Forefoot Balance Test is better able to measure balance for women who have high level function compared to tests such as single leg stance on foam.

**Measurement of age-based differences in balance in women**

There was a relationship between age and the Unilateral Forefoot Balance test, with performance times decreasing with age. Figure 3. Despite the small age range in this study (58-69 years, compared to studies across the lifespan), age still correlated significantly, albeit weakly, with the Unilateral Forefoot Balance Test (r = -0.21. Table 2). To further investigate the association with age, the cohort was divided into oldest and youngest (above and below the mean age of 62). A significant difference between the median scores for the Unilateral Forefoot Balance Test was observed (Table 3), demonstrating that the test is sensitive to differences in balance for those women entering their sixties and those in their mid sixties.
Construction of normative data for clinical use

A condensed simplified version of normative data (left and right limbs combined as averages) for clinical use is presented in Table 3. As we identified a significant age-related difference in balance across range of 58-69 years, data are presented in subgroups, for women with a mean age of 60 and a mean age of 64. Median times are reported where the scores were not normally distributed. The tests reported include the new ‘Unilateral Forefoot Balance Test’; Single Leg Stance in the eyes open and eyes closed conditions; Single Leg Stance on foam with eyes open and the Step Test. The results for the single leg stance on foam with eyes closed condition was not presented, as median times were too short (1-2 seconds) to be measured reliably.

Table 2. Correlations for best performance for all of the balance tests

<table>
<thead>
<tr>
<th>Age</th>
<th>UNILATERAL FOREFOOT BALANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>P value</td>
</tr>
<tr>
<td>-.210</td>
<td>.013</td>
</tr>
<tr>
<td>-.164</td>
<td>.052</td>
</tr>
<tr>
<td>-.127</td>
<td>.135</td>
</tr>
<tr>
<td>-.206</td>
<td>.014</td>
</tr>
<tr>
<td>-.174</td>
<td>.038</td>
</tr>
<tr>
<td>-.201</td>
<td>.018</td>
</tr>
</tbody>
</table>

DISCUSSION

This study describes a new high-level balance test, the Unilateral Forefoot Balance Test which measures ability to maintain stance on one foot for up to 30 seconds. The findings demonstrate high test-retest reliability and concurrent validity for women entering their sixties. This new test provides the clinician with an additional assessment tool where standard tests are insufficient. It is noteworthy that with median performance times of 5-6 seconds, the Unilateral Forefoot Balance Test may only be appropriate in the clinical setting for high functioning women of this age range. For example, the test would be suitable for the very fit older person returning to physical activities. In conditions of greater impairment, where unilateral forefoot balance is too difficult, the currently available balance tests could be used instead.

This new test also has potential for screening younger women for the early signs of loss of balance. The finding that performance time was significantly worse for women with a mean age of 64 compared to those with a mean age of 60 demonstrates that...
Table 3. Simplified normative data table for tests of balance for age-based subgroups of women aged 58-69. Medians rather than means are reported as the distribution of scores were not uniform. Times have been rounded to whole or 0.5 seconds. Performance values represent right and left limbs combined. % = percentile. In the 62-69 year age group, the Unilateral Forefoot Balance Test is appropriate for very high functioning women only.

<table>
<thead>
<tr>
<th>Test</th>
<th>Age 58-61.9, mean = 60 years (n=88)</th>
<th>Age 62-69, mean = 64 years (n= 54)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (seconds)</td>
<td>Interquartile range</td>
</tr>
<tr>
<td>Unilateral Forefoot Balance Test best</td>
<td>6.5</td>
<td>4 - 13</td>
</tr>
<tr>
<td>Single leg stance eyes open best</td>
<td>30</td>
<td>30 - 30</td>
</tr>
<tr>
<td>Single leg stance eyes closed best</td>
<td>8</td>
<td>4 - 14</td>
</tr>
<tr>
<td>Single leg stance on foam best</td>
<td>30</td>
<td>20 - 30</td>
</tr>
<tr>
<td>Step test (number in 15 seconds)</td>
<td>20</td>
<td>18 - 23</td>
</tr>
</tbody>
</table>

the test is sensitive to subtle differences associated with aging. Previous studies have identified age related changes in women across decades (Low Choy et al 2003, Isles et al 2004) whereas this new test identified differences within a decade. Thus the test has potential to be of use in the younger population.

Decline in strength with age is associated in part with decline in balance and is therefore relevant in the assessment of age related decline in balance (Iverson et al 1990) (Lord and Clark 1996). The Unilateral Forefoot Balance Test requires strength combined with ability to maintain equilibrium. This would explain in part the decreased balance observed in the older women in this study. This study adds to previous reports of decline in balance in women prior to the age of 65 (Briggs et al 1989, Low Choy et al 2003) and highlights the need for the early intervention of physical programmes to maintain balance skills and prevent falls. Plantar flexion strength can assist in controlling forward movement over the forefoot, thereby preventing loss of balance in the forward direction. The unilateral forefoot balance test requires more strength than single leg stance and this is relevant functionally where putting up with the stance leg assists clearance with the leading leg, thereby avoiding tripping.

In this investigation of age and balance it was found that the older women experienced more difficulty performing the tests with eyes closed, especially on the foam surface, suggesting that the vestibular and proprioceptive systems become less efficient with age, resulting in greater dependence on visual cues. Indeed, Choy et al identified that the removal of visual cues affects balance in women as young as 40 (Low Choy et al 2003). The number of otoliths and hair cells in the vestibular apparatus decrease with age which could contribute to decreased vestibular sensitivity (Johnson 1971, Rosenthal and Rubin 1975). The ‘Balance Error Scoring System’ (BESS) (Riemann et al 1999) found that deficits in concussed athletes were best identified by testing single leg stance in the condition of eyes closed, on foam (Riemann and Guskiewicz 2000). Although this test is relevant to vestibular functioning, it may be too difficult for the aging population, as demonstrated by the low performance by women in this condition in our study.

Joint degeneration associated with aging will also contribute to decline in balance (Wyke 1979) as it will affect proprioception and reaction at the ankle and foot of the support leg. The Unilateral Forefoot Balance Test may also be useful in identifying deficits in patients who have a mild brain or peripheral injury affecting proprioception.

A simplified normative table for balance tests on women for use by clinicians was constructed. The table is categorized for the age groups 58-61.9 and 62-69 years, as there was a statistically significant difference between these groups. Medians and quartiles are provided to give information regarding normal performance, and to provide clinicians with information to determine the relative performance of the patient. For example, an individual performing outside the 5th percentile is an indication of sub-normal function. This is also useful in terms of measuring improvement. The large sample size, and the exclusion of women with health problems that affect balance, has resulted in robust normative data. People with musculoskeletal conditions may have lower levels of balance, and it is therefore important to exclude them from healthy normative data. The selection criteria in a previous study (Isles et al 2004) potentially included women

“the Unilateral Forefoot Balance Test is a reliable and valid test of high-level balance in women entering their sixties”
who had joint problems which may have contributed to the significantly lower balance ability observed in older women. The majority of the women could achieve ten consecutive steps of tandem walking and therefore this test is more appropriate for assessing more severe balance problems.

In comparison to other studies of balance in the aging population, the women in this study performed similarly or slightly better to that previously reported for testing conditions for up to 30 seconds. For the single leg stance test the women aged 62-69 in our study had a maximum mean time of 28.5 ± 4.8 and 27 ± 6.2 seconds for right and left compared to 27.1 ± 6.4 and 25.8 ± 6.2 in the El-Kashlan et al study (El-Kashlan et al 1998). In the eyes closed condition in single leg stance results vary slightly across various studies. In the Bohannon study men and women aged 60-69 combined had a mean time of 10.2 ± 8.6 sec, whereas in the El-Kashlan study performance time was 5 seconds. In our study, times ranged from 10 to 7 seconds for the younger and older groups respectively. It is important to note that the groups are not directly comparable due to one group having men in it, and that there can be large variation in performance across the decade 60 to 69 as identified in our study. In our study subjects were allowed to use their arms, representing a functional response to balance perturbation.

Balance times for non-institutionalized older men alone have been reported previously (Iverson et al 1990), but cannot be compared to our data due to different testing procedures. Further testing of older males will provide further information of the decline in balance in higher functioning males.

A potential limitation to this study is that the test order was constant for all participants, possibly leading to effects due to learning or fatigue. However, as the neuromuscular activity required to perform the Unilateral Forefoot Balance Test was different from that required for the other tests, it is not likely that the test order would have affected the results.

In conclusion, the Unilateral Forefoot Balance Test is a reliable and valid test of high-level balance, and is able to detect the association of age with performance time in women entering their sixties. The Unilateral Forefoot Balance Test is relevant to functional activities and incorporates components similar to those required for high-level recreational activities such as walking on uneven ground or rocks, running, tennis and netball. This new test of balance, which does not require equipment other than a stopwatch, may be of potential use to physiotherapists working with high functioning people who have mild changes in balance ability. Further research and testing of high-level patients with mild balance problems of all ages will be of great value with regards to the use of the test in clinical assessment and treatment.

Key points
This new tool is valid and reliable to assess mild loss of balance in high functioning women in their sixties. The tool can be used to test early changes in balance due to aging (such as women who are postmenopausal and may become at risk of falls and fractures). Normative data for women over 60 has been derived from a large population sample for this new test and other commonly used balance tests.

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REFERENCES


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