FOOTWEAR ASSESSMENT FORM

General shoe style / covering

- ☐ barefoot
- ☐ mule
- ☐ slipper
- ☐ walking shoe
- ☐ surgical footwear
- ☐ socks only
- ☐ high heel
- ☐ sandal
- ☐ Oxford shoe
- ☐ stockings only
- ☐ courtshoe
- ☐ mocassin
- ☐ Ugg bot
- ☐ backless slipper
- ☐ boot
- ☐ athletic shoe
- ☐ thong / flip-flop

Heel height

☐ 0 to 2.5 cm ☐ 2.6 to 5.0 cm ☐ >5.0 cm

Fixation

☐ none ☐ laces ☐ straps/buckles ☐ Velcro ☐ zips

Heel counter stiffness

☐ minimal (rigid) ☐ <45° ☐ >45°

Longitudinal sole rigidity

☐ minimal (rigid) ☐ <45° ☐ >45°

Sole flexion point

☐ at MTPJs ☐ before MTPJs

Tread pattern

☐ textured ☐ smooth ☐ partly worn ☐ fully worn

Sole hardness

☐ soft ☐ firm ☐ hard

FOOTWEAR ASSESSMENT FORM

General shoe style / covering

Select from sixteen basic shoe styles.

Heel height

Measure using a metric ruler.

Fixation

Document as either no fixation, laces, straps/buckles, Velcro™ or zippers.

Heel counter stiffness

Exert firm pressure half way up the posterior aspect of the heel. The degree of buckling of the heel counter relative to vertical is visually estimated and categorised as minimal (i.e. rigid), less than 45 degrees, or greater than 45 degrees

Longitudinal sole rigidity

Exert firm pressure to the front of the shoe while the rear part of the shoe is stabilized. The degree of sole flexion relative to the horizontal plane is visually estimated and documented as minimal, less than 45 degrees, or greater than 45 degrees.

Sole flexion point

Defined as the point at which the sole flexes first when pressure is applied performing the previous test. Document as either occurring at the level of the metatarsophalangeal joints or proximal to the metatarsophalangeal joints.

Tread pattern

Observe the weightbearing region of the sole material and document as textured, smooth (i.e. no texture), partly worn or fully worn. To be documented as partly worn, an area of the sole has to be completely smooth in one area.

Sole hardness

Exert firm downwards pressure on the inner region of the heel of the shoe and document as soft, firm or hard.

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The Footwear Assessment Form: a reliable clinical tool to assess footwear characteristics of relevance to postural stability in older adults

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Objective: Falls in older adults are common and may result in serious injury. Inappropriate footwear has been suggested to be a contributing factor to many falls. However no studies have been undertaken to determine whether clinicians can reliably assess footwear variables thought to influence postural stability in older adults. The aim of this study was therefore to develop a simple clinical footwear assessment form and assess its reliability, both between examiners and with repeated assessments over time.
Design: Two examiners assessed seven footwear variables (shoe type, heel height, heel counter stiffness, longitudinal sole rigidity, sole flexion point, tread pattern and sole hardness) in 12 different shoes, and repeated the measurements three weeks later. The examiners were blinded to each other's and their own previous results.
Results: Analysis using the kappa (κ) and percentage agreement statistics revealed the examiners' footwear assessments to be generally highly reliable ($\kappa = 0.47$–1.00 for inter-tester comparisons, $\kappa = 0.40$–1.00 for intra-tester comparisons), with the exception of inter-tester assessment of sole hardness ($\kappa = 0.03$–0.48).
Conclusion: The Footwear Assessment Form is a reliable clinical tool for the assessment of shoe type, heel height, heel counter stiffness, longitudinal sole rigidity and tread pattern; however, a more objective protocol may be required to improve the reliability of sole hardness evaluation. The Footwear Assessment Form can now be used with confidence in the clinical setting and in future investigations to determine the contribution of footwear characteristics to instability and falls in older adults.

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Introduction

Falls in older adults are a well-recognized public health problem. Community studies have revealed that approximately one-third of people over the age of 65 years will experience a fall every 12 months.[1–3] Injuries resulting from falls range from minor cuts and abrasions to more serious injury such as hip fracture, which often results in significant decline in functional ability.[4] Even when no physical injury results, falling may lead to loss of confidence, restriction of activity, and subsequent reduction in mobility and independence.[5–7] The cause of falls in older adults is multifactorial, encompassing poor lower limb proprioception, visual impairment, side-effects of psychoactive medications, decreased reaction time and decreased lower limb muscle strength.[8–10] In addition to these intrinsic factors, falls may also be caused by extrinsic factors including environmental hazards[11] and unsafe footwear.[12–14]

Wearing inappropriate footwear has been associated with falls by a number of authors. Barbieri conducted interviews with older people who had fallen while hospitalized, and found that 'poorly fitting' shoes played a role in 51% of cases.[12] In a prospective study of 100 older subjects, Gabell *et al.* reported that 45% of the subjects who fell were wearing 'unhelpful' footwear at the time, including boots with cutaway heels, heavy boots and slippers with worn soles.[13] Similarly, Finlay evaluated footwear in 274 patients admitted to a geriatric unit and day hospital, and reported that only 53% were wearing 'adequate' footwear. A number of potentially detrimental footwear features were observed, including high heels, narrow heels and heel slippage.[14] More recently, Frey and Kubasak reported a positive association between wearing cushioned athletic footwear and increased risk of falls in 106 community-dwelling older people.[15]

In response to the apparent association between inappropriate footwear and falls in older people, a number of authors have developed recommendations as to which shoe design features older people should avoid. Features thought to be detrimental to stability include high heels, slippery soles, soft soles and nonsupportive heel collars.[14,16–18] However, few investigations have directly assessed the effect of each of these variables on stability and falls in older people. Lord and Bashford have shown that high heels impair performance in standing balance tests in older women,[19] while Robbins and colleagues have reported that shoes with very soft midsoles impair beam walking performance[20] and foot position sense[21] in older men.

Despite the suggestion that certain footwear characteristics may be implicated in falls in older people, no studies have adequately assessed whether clinicians can reliably assess footwear variables. This is somewhat surprising, as modern footwear varies considerably, and footwear assessment is considered to be a highly subjective component of a clinical examination.[22,23] Therefore, as part of a larger project investigating the types of shoes worn at the time of a fall-related hip fracture in a cohort of older women, this study was undertaken to determine whether clinicians can reliably assess footwear variables considered to be of importance in the context of postural stability in older adults.

Methods

Development of the Footwear Assessment Form

The authors developed a footwear assessment form containing information on shoe variables considered to be of importance in postural stability. The variables selected for inclusion were derived from a comprehensive review of the literature that has been published previously.[24] A number of additional variables were included based on observations of footwear and postural stability in the clinical setting. Both authors assessed a total of 40 different shoes while the form was under development. The variables included on the Footwear Assessment Form are shown in Figure 1 and the form itself is provided in the Appendix.

Shoe type

Initially, shoe type categorization was to be based on the 'seven basic shoe styles', i.e. boot, clog, sandal, Oxford, slipper, mule and moccasin. However, pilot studies revealed that a number of shoes could not be appropriately placed into one

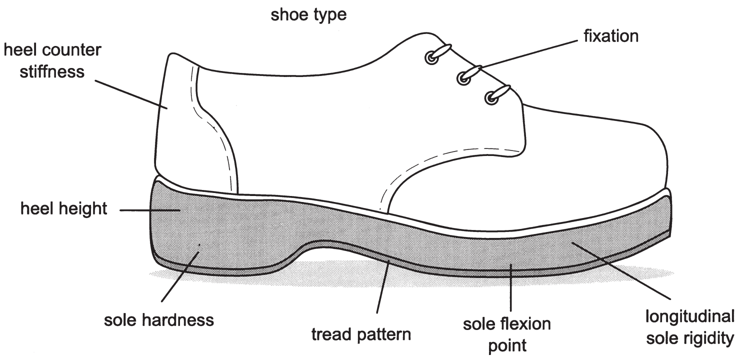

Figure 1 Footwear variables included in the Footwear Assessment Form.

of these seven categories. Therefore, a number of additional shoe styles were added to the list: high heel, courtshoe, athletic shoe, walking shoe, backless slipper, thong and surgical/bespoke footwear. Shoe type therefore involved the selection of one option from a list of 16 styles.

Heel height

Heel height was measured using a metric ruler, and documented in one of three categories: 0-2.5 cm, 2.6–5.0 cm, and above 5.0 cm.

Fixation

Shoe fixation was documented as either no fixation, laces, straps/buckles, Velcro™ or zippers.

Heel counter stiffness

Flexibility of the heel counter of the shoe was determined by the examiner exerting firm pressure half way up the posterior aspect of the heel. The degree of buckling of the heel counter relative to vertical was visually estimated and categorized as minimal, less than 45 degrees, or greater than 45 degrees (see Figure 2). Backless shoes were simply documented as 'not applicable' in this section.

Longitudinal sole rigidity

Sole rigidity was determined by the examiner exerting firm pressure to the front of the shoe while the rear part of the shoe was stabilized. The degree of sole flexion relative to the horizontal plane was visually estimated and documented as minimal, less than 45 degrees, or greater than 45 degrees. A further observation, sole flexion point, was defined as the point at which the sole flexed first when pressure was applied. Sole flexion point was documented as either occurring at the level of the metatarsophalangeal joints or proximal to the metatarsophalangeal joints (see Figure 3).

Tread pattern

The tread pattern of the weightbearing region of the sole material was observed and documented as textured, smooth, partly worn or fully worn. To be documented as partly worn, an area of the sole had to be completely smooth in one area, otherwise the tread pattern was documented as textured.

Sole hardness

The hardness of the sole of the shoe was determined by the examiner exerting firm downwards pressure on the inner region of the heel of the

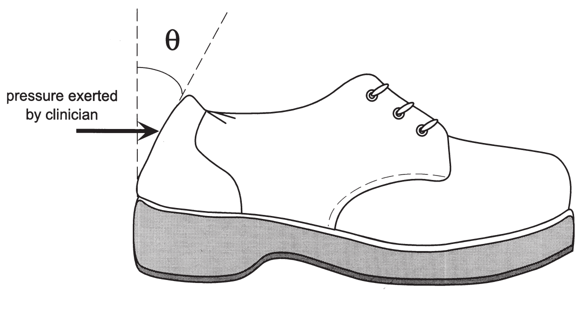

Figure 2 Assessment of heel counter stiffness. The examiner exerts firm pressure half way up the posterior aspect of the heel, and visually estimates the angle (θ) the heel counter makes from the vertical.

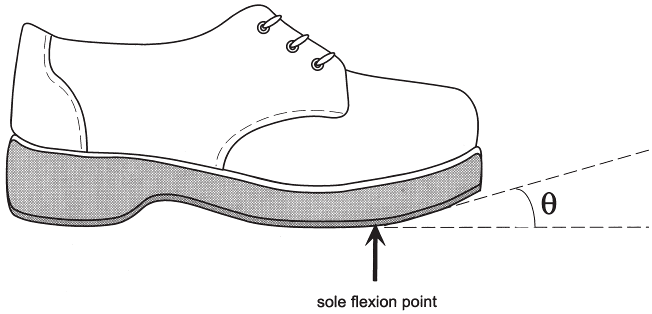

Figure 3 Assessment of longitudinal sole rigidity and sole flexion point. The examiner exerts firm pressure to the front of the shoe, and documents the angle (θ) between the sole and the horizontal as the degree of longitudinal sole rigidity. The point at which the shoe first flexes when pressure is applied is the sole flexion point.

shoe. Sole hardness was documented as soft, firm or hard.

The reliability study

Design

To assess the reliability of this scale, 12 different shoes encompassing a range of styles were selected and assessed by two examiners: a podiatrist (examiner 1) and a physiotherapist (examiner 2). This process was then repeated three weeks later to determine intra-tester reliability. Examiners were blinded to each other's and their own previous results.

Statistical analysis

Ratings were analysed using the percentage agreement and kappa (κ) statistics for both inter- and intra-tester comparisons. Percentage agreement is a reliability test for categorical variables, estimating the ability of examiners to agree on category ratings.[25] Although some variables included in our assessment could be considered to be ordinal data (e.g. heel height), this stringent statistic was considered appropriate as it was felt that even partial disagreement on the ordinal variables actually represents total disagreement in the clinical context.

The kappa (κ) statistic is a chance-corrected measure of agreement which takes into account not only the proportion of the observed agreements, but also the proportion of agreements expected by chance.[26] That is, it not only calculates the number of times examiners totally agree, but also considers the number of options they had to choose from to reach their decision. Kappa values above 0.8 represent excellent agreement; from 0.6 to 0.8 substantial agreement, from 0.4 to 0.6, moderate agreement; and below 0.4, poor to fair agreement.[27]

Results

Inter-tester kappa and percentage agreement results are shown in Table 1. The kappa statistic shows that inter-tester reliability in both sessions was excellent for assessment of shoe type, fixation and tread pattern, and substantial for heel counter stiffness. Generally there was little difference in reliability between the two sessions, however assessment of sole flexion point was substantial in session 1, but improved in session 2 to exhibit excellent reliability.

Intra-tester kappa and percentage agreement results are shown in Table 2. The kappa statistic shows that intra-tester reliability was excellent in both examiners for tread pattern. Some differences were observed between the examiners for specific observations. Reliability for the assessment of shoe type, fixation and heel counter stiffness was excellent for examiner 2, but only substantial in examiner 1. Alternatively, assessment of sole flexion point assessment was substantial for examiner 1, but only moderate for examiner 2. Reliability of sole hardness assessment was substantial in examiner 2, but only moderate in examiner 1.

A number of assessments produced very low

Table 1 Inter-tester reliability

	Session 1		Session 2	
Variable	κ[a]	% agreement	κ[a]	% agreement
Shoe type	0.80	83	0.90	92
Heel height	–0.09	83	1.00	100
Fixation	0.87	92	0.87	92
Heel counter stiffness	0.75	83	0.64	75
Longitudinal sole rigidity	0.47	92	–0.04	92
Sole flexion point	0.75	92	1.00	100
Tread pattern	1.00	100	0.85	92
Sole hardness	0.48	67	0.03	42

[a]Kappa values above 0.8 represent excellent agreement; from 0.6 to 0.8 substantial agreement, from 0.4 to 0.6, moderate agreement; and below 0.4, poor to fair agreement.

Table 2 Intra-tester reliability

	Examiner 1		Examiner 2	
Variable	κ[a]	% agreement	κ[a]	% agreement
Shoe type	0.70	75	1.00	100
Heel height	–0.04	92	0.62	92
Fixation	0.73	83	1.00	100
Heel counter stiffness	0.77	83	0.86	92
Longitudinal sole rigidity	1.00	100	–0.04	92
Sole flexion point	0.62	92	0.40	83
Tread pattern	0.85	92	1.00	100
Sole hardness	0.58	75	0.73	83

[a]Kappa values above 0.8 represent excellent agreement; from 0.6 to 0.8 substantial agreement, from 0.4 to 0.6, moderate agreement; and below 0.4, poor to fair agreement.

kappa values (inter-tester reliability of heel height, longitudinal sole rigidity and sole hardness, and intra-tester reliability of heel height, and longitudinal sole rigidity), however the percentage agreement for each of these assessments was in the range of 83–92%. This appears to be an example of the high-agreement–low-kappa paradox caused by a low prevalence of some scores.[28] That is, a meaningful kappa value cannot be calculated when there is a very small number of selected items for a particular variable. For example, in the assessment of heel height, examiner 1 selected 0–2.5 cm in all but one case, and as such, the prevalence of 2.5–5.0 cm and above 5.0 cm heel height selections was insufficient to enable kappa to be correctly calculated. For each of the assessments with low kappas due to low prevalence of scores, the percentage agreement statistic provides a better indicator of overall agreement than the kappa value.

Discussion

The contribution of footwear to postural instability and falls in older people has received relatively little attention in the literature, despite the fact that a large proportion of falls occur when older people are walking[29–31] or negotiating common obstacles such as poorly maintained footpaths or stairs.[2,31–33] To adequately assess the contribution of different styles of footwear and footwear design features to falls, large-scale studies need to be undertaken to assess the interaction between the circumstances of the fall event and the shoe worn at the time. Due to the wide range of shoes currently available, clinicians and researchers must be able to agree on their footwear assessments to enable valid comparisons to be drawn.

In this study, we have shown that the use of a simple footwear assessment form enables clini-

Clinical messages

- Evaluating the relationship between footwear and falls requires a reliable clinical assessment tool to ensure agreement between clinicians and with repeated assessments over time.
- The assessment form described in this study is reliable for the assessment of shoe type, heel height, heel counter stiffness, longitudinal sole rigidity and tread pattern, however a more objective protocol may be required to improve the reliability of sole hardness evaluation.

cians to reliably evaluate footwear characteristics considered to influence stability in older adults. With only one major exception, each of the variables could be reliably documented both between the two examiners and within each examiner over time, despite the inherent subjectivity of the task, the wide range of shoe types assessed, and the stringent statistical analysis employed. When used in the field, it is likely that the agreement of shoe characteristics would be even greater than that reported here, as the range of shoes evaluated in this study was much broader than the number of different shoe types regularly worn by older adults in their household environment.[34]

The only exception to the generally high reliability reported in this study was the inter-tester assessment of sole hardness. Assessing the hardness of a shoe sole is of some importance in falls prevention, as recent work by Robbins and colleagues suggests that soft-soled shoes may impair balance by inducing a state of 'pseudo-neuropathy' on the sole of the foot.[20,21,35] The assessment of sole hardness required the examiners to exert firm downward pressure on the heel region of the shoe and rate the material as soft, firm or hard. Clearly, this procedure is highly subjective, and the result obtained is dependent on both the consistency of the midsole material itself and the degree of pressure exerted by each examiner. If greater reliability is required for this component of the assessment between examiners, the simple clinical test described here may need to be replaced with quantitative instrumentation, such as the Shore A standard test for durometer hardness.[36]

The validity of some of the more subjective footwear assessments used in this study is difficult to determine, as few clearly defined guidelines exist. For example, our evaluation of heel counter stiffness used arbitrary units of 45 degrees, as this was felt to provide some distinction between a 'stiff' shoe and a 'flexible' shoe. Stiff heel counters are generally regarded as being a beneficial feature, to assist in retaining the shape of the upper and to control a certain amount of heel movement within the shoe during gait.[37] However, no objective measures of heel counter stiffness currently exist. Similarly, the longitudinal rigidity of the shoe sole also used an arbitrary 45-degree scale, with an additional observation of where the sole flexed when pressure was applied. This additional observation was included as it is generally accepted that dorsiflexion of the metatarsophalangeal joints is required for normal gait,[38–40] and as such, the shoe should flex at the level of the metatarsophalangeal joints to enable the foot to propel the body efficiently when walking.[22] Although the scales used in these components of the form are rather arbitrary, we believe that the instrument provides valid information regarding each of the variables assessed, and should enable clinicians and researchers to appropriately delineate shoes with firm or soft heel counters and shoes with flexible or inflexible soles.

Despite the high reliability and face validity of the Footwear Assessment Form, as a clinical tool it has a number of limitations. First, because the form was specifically developed to evaluate shoe design features thought to influence postural stability in older adults, there are many other clinically important footwear variables that were not addressed. No attempt was made to determine whether the shoes were of adequate depth or width to accommodate hallux valgus or hammertoe deformities, a variable which is of considerable importance when considering footwear for older adults at risk of developing foot ulceration.[41,42] Secondly, the form does not include any information regarding an older person's perceptions of their footwear, or the underlying criteria used to select their shoes for purchase. This may be an important factor in the context of falls, as it has been shown that many older adults are not aware of the ramifications of inappropriate footwear, and base their shoe selection on comfort rather than safety.[34,43] Despite these limitations, we feel the form assists the clinician in obtaining functionally important information about footwear, and will be of considerable benefit in future investigations to determine the relationship between footwear and falls in the older population.

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Appendix – the Footwear Assessment Form

General shoe style/covering

❍ barefoot ❍ socks only ❍ stockings only ❍ backless slipper
❍ mule ❍ high heel ❍ courtshoe ❍ boot
❍ slipper ❍ sandal ❍ moccasin ❍ athletic shoe
❍ walking shoe ❍ Oxford shoe ❍ ugg boot ❍ thong
❍ surgical/bespoke footwear

Heel height

❍ 0–2.5 cm ❍ 2.6–5.0 cm ❍ >5.0 cm

Fixation

❍ none ❍ laces ❍ straps/buckles ❍ Velcro™ ❍ zips

Heel counter stiffness

❍ minimal ❍ <45° ❍ >45°

Longitudinal sole rigidity

❍ minimal ❍ <45° ❍ >45°

Sole flexion point

❍ at level of MTPJs ❍ before MTPJs

Tread pattern

❍ textured ❍ smooth (i.e. no pattern) ❍ partly worn ❍ fully worn

Sole hardness

❍ soft ❍ firm ❍ hard