

Peripheral vestibular dysfunction is prevalent in older adults experiencing multiple non-syncopal falls versus age-matched non-fallers: a pilot study

MATTHEW BRYAN LISTON¹, DORIS-EVA BAMIOU^{2,3}, FINBARR MARTIN⁴, ADRIAN HOPPER⁴, NEHZAT KOOHI³, LINDA LUXON³, MAROUSA PAVLOU¹

¹Centre of Human and Aerospace Physiological Sciences, King's College London, London, UK

²Ear Institute, University College London, London, UK

³Department of Neuro-Otology, National Hospital for Neurology and Neurosurgery, London, UK

⁴Department of Elderly Care Medicine, St Thomas' Hospital, London, UK

Address correspondence to: M. Pavlou. Tel: 00 44 (0) 207 848 6328; Fax: 00 44 (0) 207 848 6325. Email: marousa.pavlou@kcl.ac.uk

Abstract

Background: vestibular disorders are common in the general population, increasing with age. However, it is unknown whether older adults who fall have a higher proportion of vestibular impairment compared with age-matched older adult non-fallers.

Objective: to identify whether a greater proportion of older adult fallers have a peripheral vestibular impairment compared with age-matched healthy controls.

Design: case-controlled study.

Setting: tertiary falls and neuro-otology clinics and local community centres, London, UK.

Participants and methods: community-dwelling older adults experiencing: (i) ≥ 2 unexplained falls within the previous 12-months (Group F, $n = 25$), (ii) a confirmed peripheral vestibular disorder (Group PV, $n = 15$) and (iii) healthy non-fallers (Group H, $n = 16$). All the participants completed quantitative vestibular function tests, the functional gait assessment (FGA), physiological profile assessment (PPA) and subjective measures for common vestibular symptoms (i.e. giddiness), balance confidence during daily activities and psychological state.

Results: a clinically significant vestibular impairment was noted for 80% (20/25) of Group F compared with 18.75% (3/16) for Group H ($P < 0.01$). Group F performed less well in complex gait tasks (FGA), and reported a greater number of falls than both Groups H and PV ($P < 0.05$). Vestibular symptom scores showed no significant difference between Groups F and PV.

Conclusion: vestibular dysfunction is significantly more prevalent in older adult fallers versus non-fallers. Individuals referred to a falls clinic are older, more impaired and report more falls than those referred to a neuro-otology department. A greater awareness of vestibular impairments may lead to more effective management and treatment for older adult fallers.

Keywords: falls, vestibular, balance, older people

Introduction

Postural control is mediated by central processes dependent on the integration of peripheral sensory inputs, mostly arising from the visual, proprioceptive and vestibular systems. Age-related decline in physical and sensory functions with an impaired ability to integrate sensory information appropriately is well documented [1–3]. Altered

function of the postural control system with increasing age may lead to impaired balance and increased falls risk in older adults.

Although longitudinal studies have identified reduced vestibular function with advancing years [3], most studies concentrate on the visual and somatosensory systems' contribution to falls risk. Despite recent work associating asymmetric vestibular function, ascertained solely from a clinical examination,

with wrist and hip fractures [4, 5] and poorer Dynamic Gait Index scores with greater dynamic visual acuity impairments [6], the relationship between vestibular impairment and falls risk in older adult fallers remains under-investigated.

Multifactorial balance assessments in older adults often exclude a comprehensive clinical vestibular component [7]. Studies indicating greater vestibular dysfunction in fallers base this on non-clinical or low sensitivity [4, 5, 8] tests, which can be influenced by co-morbid conditions or secondary effects of the ageing process (i.e. dynamic visual acuity) [6], and without clearly differentiating fallers from non-fallers or including healthy age-matched controls [9]. It is, therefore, difficult to ascertain how prevalent vestibular impairment is in a clinical sample of older adults who experience multiple non-syncopal falls compared with age-matched healthy adults and whether this impairment is a main contributor to their falls risk.

Furthermore, while studies demonstrate increased falls risk in people with vestibular dysfunction [10, 11], it is unknown whether clinical characteristics differ between older adults referred to a falls versus a neuro-otology clinic.

The study aims were to (i) assess whether a greater proportion of older adult fallers have a peripheral vestibular impairment identified on the basis of history and comprehensive testing compared with age-matched healthy controls and (ii) compare subjective symptoms, balance confidence, falls risk and functional gait assessment (FGA) between older adults referred to a falls versus a neuro-otology clinic.

Methodology

Participants

Participants were aged ≥ 65 years old and medically screened for exclusion criteria including musculoskeletal and neurological deficits that may significantly affect postural instability; cognitive impairment was screened using the abbreviated mental test score ($< 8/10$) [12]. A convenience sample from three participant groups was recruited:

- Older adult fallers (Group F, $n = 25$) from falls clinics within the Southwark and Lambeth Integrated Care Pathway for Fallers (London, UK). Inclusion criteria were ≥ 2 non-syncopal falls during the previous 12-months clinically attributed to postural instability not due to significant hazards (i.e. blindness) and no vertigo history after falls onset. Individuals with cardiac syncope/pre-syncope, acute illness, medication side-effects or drug intoxication were excluded.
- Healthy older adults (Group H, $n = 16$) from community exercise classes (Southwark Council, London, UK).
- Individuals with a diagnosed peripheral vestibular disorder (Group PV, $n = 15$) from the Neuro-otology Department, National Hospital for Neurology and Neurosurgery (NHNN, London, UK). Inclusion criteria were a $\geq 8\%$ canal paresis on Fitzgerald–Hallpike bithermal caloric testing using optic fixation and/or presence of unidirectional spontaneous vestibular nystagmus on electronystagmography (ENG).

Local ethics committee approval was obtained and all participants provided informed consent prior to participating in the study.

Neuro-otological assessment

All the participants completed a routine neuro-otological examination. This included

- Fitzgerald–Hallpike bithermal caloric stimulation using a 40 s irrigation in each ear at 44 and 30°C.
- Horizontal direct current ENG (Easygraph recorder) of gaze ($+/-30^\circ$) with/without optic fixation, saccades (at 0° and $+/-30^\circ$, assessing for velocity and accuracy), smooth pursuit 0.2, 0.3 and 0.4 Hz (with peak velocities of 38, 56.5 and $76^\circ/s$, respectively, assessing for saccadic intrusions), optokinetic responses to a full-field striped curtain rotated at $40^\circ/s$ (assessing for symmetry). Sinusoidal rotation at 0.2 Hz with/without fixation and impulsive rotation (until nystagmus subsided, 45 s, maximum 100 s) with an initial $140^\circ/s$ acceleration/deceleration and a $60^\circ/s$ fixed-chair velocity tested the vestibulo-ocular reflex (VOR), including VOR suppression. The latter was considered normal when no measurable nystagmus was recorded during visual fixation.
- Dix–Hallpike test.

Unilateral vestibular impairment was identified based on a past history of sudden vertigo resolving within days-to-weeks and/or

- Unilateral canal paresis on caloric testing measured by the duration parameter using Jongkees' formula [13]. The British Society of Audiology Recommended Procedure Caloric Test document (<http://www.thebsa.org.uk/docs/RecPro/CTP.pdf>, 17 March 2013 date last accessed) states that individual departments should obtain their own normative duration or slow-phase velocity data to identify a clinically significant canal paresis. The threshold for the Neuro-otology Department, NHNN, London, UK is $>8\%$ in the absence of optic fixation under direction observation [13] and is lower than that obtained using the slow-phase velocity parameter [9].
- ENG unidirectional spontaneous nystagmus ($>4^\circ/s$) on gaze testing with response enhancement on removal of optic fixation.
- Right-left asymmetry of slow-phase velocity $>15\%$ on rotation testing (calculated with Jongkees' formula [14] and based on departmental normative data).

Bilateral vestibular hypofunction was based on either bilaterally absent caloric responses and/or a VOR mean slow component velocity (SCV) and/or time constant at < 2 SD of the mean for healthy controls (SCV: 32, $SD 8^\circ/s$; time constant 13.35 s, $SD 4.45$ s) for clockwise/counter-clockwise step rotation testing [15]. Central vestibular impairment was based on smooth pursuit, saccades, OKN, and VOR suppression abnormalities. Table 1 lists demographic data and vestibular findings.

Table 1. Participant characteristics

Variable	Group F (<i>n</i> = 25)	Group PV (<i>n</i> = 15)	Group H (<i>n</i> = 16)
Age (years) (mean, range)	76.6 (68–88)	70.9 (65–89)	74.5 (65–84)
Gender			
Female, <i>n</i> (%)	21 (84%)	8 (53%)	13 (81%)
Male, <i>n</i> (%)	4 (16%)	7 (47%)	3 (19%)
Number of falls last 12 months, (range, <i>n</i> % who fall)	2–6 (100%)	0–4 (40%)	0–1 (12.5%)
Vestibular impairments, <i>n</i>			
Peripheral			
CP > 8% (+DP)	7 (2)	9	0
BVH	2	4	0
DP > 15%	8	1	2
End olymphatic hydrops	0	1	0
No abnormal findings	5	0	13
Central			
Broken smooth pursuit and poor VOR suppression	1	0	1

Group F, older adult fallers; Group PV, patients with a peripheral vestibular disorder; Group H, healthy older adult participants; CP, canal paresis based on Fitzgerald–Hallpike caloric testing as measured by the duration parameter using the Jongkee's formula of >8% in the absence of optic fixation; BVH, bilateral vestibular hypofunction based on caloric and/or electronystagmography (ENG) findings; DP >15%, directional preponderance based on the presence of unidirectional spontaneous nystagmus on gaze testing with enhancement of the response on removal of optic fixation on ENG; VOR, vestibular ocular reflex.

Balance and gait measures

Dynamic computerised posturography

The Sensory Organization Test was performed according to a published protocol (Equitest; Neurocom International, Oregon, USA). Scores <70/100% are considered abnormal [16].

The FGA [17] assesses performance on complex gait tasks and is validated in people with vestibular disorders and older fallers [18]. Scores $\leq 22/30$ identify fall risk and predict falls in community-dwelling older adults within 6 months [18].

The short-form physiological profile assessment (PPA) [7] assesses falls risk and predicts future falls in older adults. Edge contrast sensitivity, knee joint proprioception, maximum isometric quadriceps strength, hand reaction time and postural sway (standing on foam, eyes open) are tested. Composite scores <0 indicate a low, 0–1 mild, 1–2 moderate and >2 high falls risk, respectively. High PPA test score variability indicates specific impairments, low variability reveals performance consistency across tests [19].

Self-report measures

The Vertigo Symptom Scale (VSS) [20] assesses common vestibular (VSS-V, e.g. giddiness, imbalance) and autonomic/somatic anxiety (VSS-A, e.g. heart pounding) symptoms. Scores range between 0 (no symptoms) and 4 (daily symptoms).

The Activities-specific Balance Confidence Scale (ABC) [21] assesses patients perceived confidence for performing 16-activities of daily living without losing balance. Scores $\leq 67/100\%$ indicate increased falls risk [22].

The Hospital Anxiety and Depression Scale (HAD) [23] assesses non-somatic anxiety (HAD-A) and depression (HAD-D) symptoms. Composite scores between 8 and 10/21 are borderline; those >10/21 indicate clinical depression or anxiety.

Falls history including falls as defined by the Kellogg International Working Group [24] was recorded retrospectively for the preceding year.

Statistical analyses

SPSS 17 (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis. Chi-square tests analysed differences in proportion of vestibular impairment between Groups F and H and gender composition; an online calculator (<http://www.vassarstats.net/prop1.html>, accessed 17 March 2013) determined 95% confidence intervals for the proportion of positive vestibular findings in Groups F and H. Between-group differences were determined using Kruskal–Wallis with *post hoc* Bonferroni adjusted Mann–Whitney tests. Spearman's correlation assessed the relationship between vestibular impairment and all other data; only significant correlations are reported. Significant results were assumed if $P < 0.05$; for *post hoc* analysis significance was assumed if $P < 0.017$.

Results

Demographics

Significant between-group differences were noted only for age ($\chi^2 = 9.41$, $df = 2$, $P < 0.01$) with Group PV significantly younger than Group F ($Z = -3.11$, $P < 0.01$).

Vestibular impairment

Vestibular impairment was significantly more prevalent in Group F (80%, $n = 20/25$; 95% CI: 60.9–91.1) compared with Group H (18.75%, $n = 3/16$; 95% CI: 6.6–43.0) ($\chi^2 = 14.86$, $df = 1$, $P < 0.01$), and showed a significant relationship with VSS-V scores whereby participants with vestibular impairment had higher (i.e. worse) scores ($r = 0.30$, $P < 0.05$).

Self-report measures

Significant between-group differences were noted only for VSS-V ($\chi^2 = 9.98$, $df = 2$, $P < 0.01$), VSS-A ($\chi^2 = 9.71$, $df = 2$, $P < 0.01$), HAD-A ($\chi^2 = 9.40$, $df = 2$, $P = 0.01$) and ABC ($\chi^2 = 15.48$, $df = 2$, $P < 0.01$) scores.

Post hoc analysis revealed significantly worse symptoms for Group F compared with Group H ($P < 0.01$) for all subjective measures except HAD-D. No differences were noted between Groups H and PV although VSS-V scores approached significance. No significant differences were noted between Groups F and PV, although the former reported a significantly higher frequency of 'feeling unsteady, about to lose balance' symptoms

Table 2. Mean (SD) scores for self-report measures

Group	VSS-V	VSS-A	HAD-D	HAD-A	ABC
F (<i>n</i> = 25)	0.39 (0.27) [‡]	1.17 (0.76) [‡]	4.56 (3.74)	7.12 (4.00) [‡]	52.64 (22.14) [‡]
PV (<i>n</i> = 15)	0.42 (0.46)	0.69 (0.49)	4.93 (4.22)	6.13 (4.19)	70.04 (24.22)
H (<i>n</i> = 16)	0.11 (0.11)	0.54 (0.39)	3.38 (2.63)	3.44 (2.50)	82.76 (11.95)

Vestibular Symptom Scale (common vestibular symptoms, VSS-S; VSS-A, autonomic/somatic anxiety symptoms); Hospital Anxiety and Depression Scale (depression, HAD-D; anxiety, HAD-A); Activities-specific Balance Confidence Scale (ABC).

[‡]Significantly different to Group H (*P* < 0.01).

lasting <2 min (VSS-V, item 18a, *Z* = -2.33, *P* < 0.05). Table 2 shows descriptive data and statistics.

Physical measures

Falls history ($\chi^2 = 36.53$, *df* = 2, *P* < 0.01), FGA ($\chi^2 = 18.78$, *df* = 2, *P* < 0.01), posturography ($\chi^2 = 8.74$, *df* = 2, *P* < 0.05) and PPA ($\chi^2 = 16.15$, *df* = 2, *P* < 0.01) scores significantly differed between-groups.

Post hoc analysis revealed no differences between Groups PV and H. Group F though had significantly worse FGA scores and reported more falls than both Groups PV and H (*P* < 0.01), and showed significantly worse posturography and PPA scores compared with Group H (*P* < 0.01). The PPA score showed only a trend towards significance between Groups PV and F. However, on individual PPA tests, Group F demonstrated significantly weaker quadriceps strength compared with Groups PV (*Z* = -3.194, *P* < 0.01) and H (*Z* = -4.175, *P* < 0.01), worse edge contrast sensitivity scores compared with Group PV (*Z* = -2.66, *P* < 0.05), and greater sway compared with Group H (*Z* = -3.217, *P* < 0.01). No significant between-group differences were noted for PPA variability. Table 3 displays descriptive data and statistics.

Discussion

This study investigated whether (i) a greater proportion of older adult fallers have a peripheral vestibular impairment compared with age-matched healthy participants and (ii) compared subjective symptoms, balance confidence, falls risk and FGA between older adults referred to a falls versus a neuro-otology clinic. As in previous studies, significant differences were noted between healthy older adults and fallers on physical measurements and subjective scores for balance confidence and anxiety with the latter performing worse [22, 25]. The new finding was that 80% of older adult fallers had an unidentified vestibular impairment which has important clinical implications for the assessment and rehabilitation of this population.

Vestibular impairment and symptoms

Vestibular impairment comparisons between healthy older adults and those experiencing multiple non-syncopal falls have not previously been reported. Although this is a pilot study, results are unambiguous with significantly greater vestibular impairment identified in older adult fallers compared

Table 3. Mean (SD) of physical measures

Group	FGA	CDP	PPA
F (<i>n</i> = 25)	14.24 (5.58) ^{*‡}	48.71 (16.58) [‡]	2.64 (1.29) [‡]
PV (<i>n</i> = 15)	20.33 (6.18)	55.47 (16.91)	1.51 (1.29)
H (<i>n</i> = 16)	23.19 (4.69)	65.19 (16.17)	0.93 (0.94)

FGA, functional gait assessment; CDP, computerised dynamic posturography; PPA, short-form physiological profile assessment.

^{*}Significantly different to Group PV (*P* < 0.01).

[‡]Significantly different to Group H (*P* < 0.01).

with age-matched healthy participants. This was a ‘hidden’ problem not identified during the routine clinical falls assessment. One reason for non-detection may be that the majority of Group F participants did not report vertigo or dizziness during the period of the falls, both commonly reported symptoms in patients with vestibular impairments.

Dizziness and vertigo symptom reports increase with advancing years and dizziness is one of the most frequent complaints in older adults presenting to a primary care practice [26]. These symptoms are associated with falls and various domains (e.g. cardiovascular, sensory, medication), and have been postulated as a geriatric syndrome [27]. ‘Dizziness’ in isolation though is a non-specific symptom. Vestibular vertigo has been defined as rotational (self- or object-motion illusion), positional (vertigo or dizziness provoked with head position change) or recurrent dizziness with nausea, gaze and/or postural instability, and was found to be three times more frequent in older compared with younger people [28]. In our study, 32% (8/25) of Group F participants reported rotational vertigo, of which 75% had a vestibular impairment. Interestingly, none of these fallers were identified as having a potential vestibular disorder in the falls clinic possibly due to a lack of inquiring about these symptoms. However, as stated above, the majority of fallers diagnosed with vestibular impairment (70%) reported no dizziness or vertigo.

A significant positive relationship was noted between vestibular impairment and worse VSS-V scores. VSS-V scores were similar for both Groups PV and F, yet lower (i.e. better) compared with those in younger people with peripheral vestibular disorders [20]. Furthermore, Group F reported significantly greater ‘unsteadiness’ symptoms compared with Group PV. For Group F, the non-report of dizzy or vertigo symptoms and predominant symptom of unsteadiness most likely contribute to the fact that vestibular impairment was not considered as a possible contributing factor for their

falls. In the U.S. National Audit Survey, one-third of people with vestibular dysfunction did not report dizziness [1]. These together with our findings highlight the need to incorporate vestibular function testing within the routine falls assessment for all patients, not just those clearly reporting vertigo or dizziness.

Physical measures

Fallers display significantly greater functional gait impairment than both Groups PV and H. However, mean FGA and posturography scores indicate increased falls risk, poorer ability to perform complex gait tasks and maintain standing balance when sensory integration is required for both Groups F and PV as previously reported [18]. This is unsurprising as evidence indicates people with vestibular disorders fall frequently [1, 5, 8–10], although falls incidence for people aged ≥ 65 with unilateral vestibular impairment, as identified in the majority of Group F and PV participants, is similar to that for age-matched healthy community-dwelling adults [10]. Group F, however, reported significantly more falls compared with Groups PV and H, whereas no significant differences were noted between the latter. PPA findings may explain this discrepancy.

All groups demonstrated increased falls risk based on PPA scores, with Group F having a significantly higher risk than Group H. Variability levels were similar between-groups, indicating consistency across measures, and therefore did not influence the falls risk score. Rather, a general decline in ability across measures was responsible for increased PPA scores, with significant differences between Groups F and PV (strength, vision) and H (strength, postural sway). Although Groups PV and F are similar with regard to vestibular impairment, Group F is older, weaker, has greater gait impairment and experiences multiple falls.

Vestibular impairment may be overlooked in older adults presenting with a falls history, unsteadiness and occasionally with dizziness. Conversely, younger, fitter individuals with greater ability to perform complex gait tasks yet reporting comparable levels of vestibular type symptoms are referred to a neuro-otology clinic. Lawson *et al.* [29] described similar referral patterns whereby individuals with undiagnosed benign paroxysmal benign vertigo (BPPV) were more commonly referred to a falls rather than a specialist ENT service if older, reported falls and dizziness of more than one aetiology, e.g. BPPV, orthostatic hypotension. The high prevalence and atypical presentation of vestibular impairment in older adults must be recognised within falls clinic settings to ensure appropriate assessment and treatment.

Practice implications

The British and American Geriatrics Society joint guideline for falls prevention [30] recommends a balance, gait and mobility assessment, but vestibular testing is not explicitly incorporated. Our findings demonstrate current guidance may benefit from including vestibular testing, or increasing

awareness of vestibular pathology when assessing older adults presenting with multiple non-syncopal falls.

Non-diagnosis of vestibular impairment has important implications for falls interventions. Customised vestibular rehabilitation incorporating appropriate movements and sensory exposure is the mainstay of treatment for people with vestibular disorders. Approximately 50–80% achieve significant symptom, gait and postural stability improvements and age is not a barrier to physical input effectiveness in vestibular compensation [11]. Exercise recommendations for improving postural stability do not currently include a vestibular component [30]. Therefore, unless vestibular dysfunction is clearly identified, it is unlikely to be addressed within a falls intervention programme.

Conclusion

Vestibular impairment is significantly more prevalent in Group F compared with Group H, with the former reporting lower balance confidence, greater anxiety, vestibular symptoms, and functional impairments. Vestibular symptom severity did not differ between individuals referred to a falls versus a neuro-otology clinic. However, the former are older, report more falls, and demonstrate reduced function across a range of physical measures. Increased awareness of vestibular dysfunction and its presentation in fallers is imperative to aid clinical assessment, management and falls prevention, with associated cost-efficiencies for healthcare.

Key points

- 80% of fallers have a vestibular impairment compared with non-fallers.
- The majority of older adult fallers with vestibular impairment do not report dizziness or vertigo symptoms.
- Older adults referred to a falls versus a neuro-otology clinic are older, more impaired, and report more falls.

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