Incidence of Dizziness in the Elderly: Correlation with ocular motor, optokinetic and postural function

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The aims of the study were to: 1) determine the incidence of dizziness in a sample of elderly participants, without history of diagnosed vestibular disorders, recruited from the community; 2) measure ocular motor, optokinetic and postural function in a sample of dizzy, elderly participants in comparison to non-dizzy participants of similar age.

On the basis of their responses to the Senior Citizen's Vestibular Questionnaire, 3/35 (8.6%) elderly participants (60 years or older) were suspected to have a neurological disorder, and 5/35 (14.3%) reported experiencing dizziness on more than one occasion over the past month. Data from these 8 participants were pooled for comparison with non-dizzy participants of similar age. The timeconstant for gaze-holding to the right (ie. the time taken for the gaze position to drift centrally by 63% following extinction of the lights), but not to the left, was significantly shorter in the dizzy group compared to the comparison group. Postural instability was not significantly different between the dizzy group and the comparison group for the first 5 conditions of the Clinical Test of Sensory Interaction and Balance (CTSIB); however, in the 6th condition, in which visual, proprioceptive and somatosensory cues are reduced, only 1/8 participants (12.5%) in the dizzy group could be tested compared to 12/27 participants (44.4%) in the comparison group. The latencies to Stage 3 (but not Stage 2) circularvection (CV) were higher for the dizzy group; however, only 4 dizzy participants could be tested because of the severity of their condition. These results support the hypothesis that dizziness is a major problem amongst the elderly community and suggest that it may be associated with specific impairments of the vestibular reflexes.

Dizziness is defined as a perceived disturbance of the spatial relationship between the self and the external world (Baloh, 1994; Furman & Cass, 1996). The term *vertigo* refers specifically to the illusion of self-motion (usually rotation), originating within the self, although it has often been confused with dizziness (Baloh, 1994; Furman & Cass, 1996). One problem is that, compared to visual, auditory and somatosensory function, there is no obvious vocabulary for describing the psychological experience of abnormal vestibular sensations, and this makes diagnosis of vestibular disorders difficult. Even once possible cardiovascular causes of dizziness are excluded, the differential diagnosis of vestibular disorders is very complicated and includes traumatic, toxic, bacterial, viral, vascular and metabolic etiologies, in addition to tumours and conditions such as Meniere's disease (Baloh & Honrubia, 1990; Baloh, 1994; Furman & Cass, 1996). Unfortunately, there are also many forms of vestibular dysfunction that have no clear etiology, some of which may be due to natural variation in vestibular function within the population, and deterioration of the vestibular system as a result of aging (Baloh & Honrubia, 1990).

Dizziness is thought to be a major problem in the elderly (ie. over 60 years of age). From a sample of 1000 people aged 65 or older, Colledge, Wilson, Macintyre and MacLennan (1994) determined that 30% had experienced episodes of dizziness, and 80% had experienced these symptoms for more than 6 months. They estimated that, for every 5 years of increasing age, there was a 10% increase in the probability of suffering from dizziness. The incidence of dizziness in the elderly has alarming implications for the frequency of falls (Campbell, Robertson & Gardner, 1995). O'Loughlin, Robitaille, Bovin and Suissa (1993) found that 30% of people over 65 fall at least once a year and that those suffering from dizziness were twice as likely to fall. In a study conducted in Canada, Winter (1995) reported that the number of deaths caused by falls in the elderly was 185.6 per 100,000, compared to 21.5 per 100,000 deaths caused by motor vehicle accidents for 15 to 29 year olds. Aside from the risk of injury and death, many elderly people suffer from anxiety, lack of confidence and lost independence as a result of their fear of falling, and it has been suggested that the fear of falling may be even more problematic than the falls themsleves (Burker, Wong, Sloane, Mattingly, Preisser & Mitchell, 1995). There is some evidence that dizziness is more prevalent amongst elderly women; however, this may simply be due to the longer life expectancy for women (Lord, Russell & Webster, 1991; Katsarkas, 1994). Although a number of studies have shown that aging is associated with reduced vestibulo-ocular, vestibulo-spinal and optokinetic reflex function (Peterka, Black & & Schoenhoff, 1990; Paige, 1992; Paige, 1994; Baloh, Fifie, Zwerling, Socotch, Jacobson, Bell & Beykirch, 1993; Baloh, Jacobson & Socotch, 1994; Matheson, Darlington & Smith, 1998), and both the peripheral and central vestibular systems undergo some degeneration (e.g, Johnson & Hawkins, 1972; Lopez, Honrubia & Baloh, 1997), these deficits have been found in elderly people without dizziness or vertigo, and so their relationship to the phenomenon of dizziness is unclear.

The aim of the current study was twofold: 1) to determine the incidence of dizziness in a sample of elderly participants (ie. over 60 years of age) without a history of diagnosed vestibular dysfunction; 2) to evaluate ocular motor, optokinetic and postural function in the dizzy elderly participants compared to non-dizzy elderly participants of similar age. To our knowledge, this is the first study of the incidence and characteristics of dizziness in a New Zealand population.

Methods

Participants

Participants, aged 60 or over, were recruited via the Director of Age Concern, Otago, who provided contact with Sixties Plus, Dunedin, and the Dunedin North, Dunedin Central and Mornington Probus Clubs. Information sheets were distributed at each group's monthly meetings and members who considered themselves to be healthy, with normal balance, volunteered if they wished to participate. A total of 35 participants, 10 males and 25 females, responded, ranging in age from 60 to 83 years. They were required to complete the Senior Citizen's Vestibular Questionnaire, comprised of 13 questions designed to identify participants who might have an undiagnosed vestibular disorder. This paper will focus on 8 participants who were suspected to suffer from dizziness or a more serious vestibular/cerebellar disorder on the basis of their responses to the Senior Citizen's Vestibular Questionnaire. These participants, along with the remaining 27 participants, were assessed using tests described below. All procedures complied with the requirements of the University of Otago Ethics Committee.

Ocular Motor Function

Participants' ability to maintain lateral gaze, a test of the integrity of ocular motor function, was measured using electro-oculography (EOG) (McDermott, Matheson, Titov, Darlington & Smith, 1999). The participant was seated 115 cm in front of a wall chart, on which 4 orange squares were spaced horizontally at 10 and 20° on either side of a center square. EOG electrodes (3M Red Dot (2258-3 or neonatal 2269T-3)) were placed on the outer canthus of each each eye after the skin was cleaned with 100% ethanol; a ground electrode was attached to the centre of the forehead (McDermott, Matheson, Titov, Darlington & Smith, 1999). The output from the electrodes was amplified by a MacLab bioamplifier (50 Hz low pass filter, 1 Hz high pass filter, with a notch filter at 50/60 Hz), connected to a MacLab data acquisition system with a maximum sampling frequency of 100 kHz, and a Macintosh LCII computer running the Chart program (version 3.3.5; sampling frequency 20 Hz). The resolution of this system was approximately 1.5° of eye movement; however, due to the possibility of electrode drift, measurement error was estimated to be ± 5° (McDermott, Matheson, Titov, Darlington & Smith, 1999).

Before testing began, the calibration of the system was checked by asking the participant to stare straight ahead at the center square, then to generate eye movement to the first or second square on the left or right without head movement. During this procedure, the main lights were extinguished and the wall chart was illuminated by a desk lamp. Following this initial calibration procedure, the participant was asked to look 20° to the left with head stationary, and to maintain gaze at this position. The lamp light was then extinguished for 30 secs to determine if the participant could maintain this eye position in darkness. The procedure was then repeated for 20° to the right. Lateral gaze holding ability was measured as the time (in secs) taken for the gaze position to drift centrally by 63% of its original position following extinction of the lights (ie. the timeconstant). In this and all further analyses, data were analysed using t tests and the significance level was set at 0.05 (Zolman, 1993).

Postural Function

Postural stability was measured using a custom-built balance platform (0.5 m x 0.5 m) with a strain gauge (RadioSpares, 308118) in each quadrant which, together, detected displacement of pressure in the anterior, posterior, medial and lateral directions (McDermott, Matheson, Titov, Darlington & Smith, 1999). The output from the strain gauges was amplified by a differential bridge amplifier (low pass filter, 50 Hz; high pass filter 1 Hz; notch filter at 50/60 Hz) which averaged the difference between the outputs from the anterior and posterior strain gauges, and the medial and lateral strain gauges. The amplifier was connected to a MacLab data acquisition system with a digital-to-analog converter (maximum sampling frequency,100 kHz), and a Macintosh LCIII computer running the Scope program (version 3.5.2; sampling frequency 40 Hz). The Scope program displayed the medial/lateral data as X coordinates and the anterior/posterior data as Y coordinates (McDermott, Matheson, Titov, Darlington & Smith, 1999). At the beginning of the protocol, the participant's weight displacement was recorded and all further displacements were displayed relative to this initial displacement. In some experiments, only 2 rather than 4 strain gauges were used; while this would have affected vector analysis of body movements, it had no effect on the parameters measured in these experiments since only medial/lateral and anterior/posterior sway were measured and each participant served as his/her own control. For reasons of safety, the balance platform was surrounded by a moveable support handrail with adjustable hand grips. The postural sway of the participants' upper body was recorded using a video camera (Panasonic MV-M7) with a zoom lens, a video recorder (Mitsubishi E32 Black Diamond) and a colour monitor (Sony Trinitron). A video mixer (Panasonic digital WJ-MX) integrated the data displayed on the Macintosh computer screen with the video picture.

The Clinical Test of Sensory Interaction and Balance (CTSIB) protocol was used to investigate the contribution of visual and proprioceptive cues to postural sway (Cohen, Blatchly & Gombash, 1993; McDermott, Matheson, Titov, Darlington & Smith, 1999). According to the CTSIB, each participant's performance on the balance platform was tested: 1) with eyes open on a firm surface; 2) with eyes closed on a firm surface; 3) wearing the 'visual-vestibular conflict dome' (see below) on a firm surface; 4) with eyes open on a foam surface (to reduce normal proprioceptive cues); 5) with eyes closed on a foam surface; and 6) wearing the visual-vestibular conflict dome on a foam surface. The visual-vestibular conflict dome (adapted from Shumway-Cook & Bahling-Horak, 1986) was a dome which fitted over the head so that the participant's visual field (ie. the interior of the dome) moved in phase with head movement; the participant was asked to fixate on a black dot inside the dome during testing. In each trial, in each of the 6 conditions, the participant was instructed to stand on the balance platform with shoes on and feet together, with crossed arms and staring straight ahead. A stopwatch was used to record postural sway for 3, 30 sec trials in each of the 6 conditions; there was a 30 sec intertrial interval.

Measurements of sway were calibrated in 2 ways. First, the amount of sway, in mV, for a group of 4 participants was recorded over 3, 10 sec trials, swaying 3, 6 and 9° as measured by the wall grid behind them. An average of these values was then used as a standard to convert mV's into degrees of sway from the center of pressure. Second, the video recording of each participant, with the wall grid behind, was used to double check the amount of sway, in degrees, calculated using the Scope program, against sway as measured by the wall grid. The data obtained from the 3 trials in each of the 6 conditions were averaged to provide one value per condition for each participant. However, many participants either declined to continue the experiment into the 6th condition (ie. visual-vestibular conflict dome on foam) or the experimenter determined that it was unethical to allow them to continue based on their performance in the preceding conditions. Those who could not participate in condition 6 were given a time of 0 secs to reflect their inability to perform in this condition.

Visual-Vestibular Interaction: Latency To Circularvection

In order to assess optokinetic function, latency to circularvection, the illusion of self-rotation in response to a rotating visual field (Matheson, Darlington & Smith, 1998), was also measured. The participant was seated inside an optokinetic drum, 2 m in diameter and height, the interior of which was covered in repeating vertical black and white stripes, subtending 25° and 4° of visual angle, respectively. A light was attached to the roof of the drum, directly above the participant. The chair inside the drum was fitted with a footrest, an intercom and headphones (Darlington & Smith, 1996; Darlington & Smith, 1998). On one arm of the chair was a button that participants could press to indicate the onset of circularvection (CV); this activated a tone outside the drum which indicated the latency to CV to the experimenter. The drum was rotated at a constant 50°/sec by a DC motor. Once seated inside the drum, the participant was instructed to look straight ahead and to avoid trying to follow the stripes with eye movements once the drum was rotating. They were instructed to press the button first when they experienced self-motion in the direction opposite drum rotation ('Stage 2 CV') and then a second time when they experienced self-motion with the drum stationary ('Stage 3 CV'). The drum light remained extinguished until the drum achieved 50°/sec constant velocity rotation. The participant then received 3 trials with the light on and white noise (60-80db) delivered through the headphones, each with a 90 sec intertrial interval in darkness; between each trial, the direction of drum rotation was reversed to control for previous exposure (Darlington & Smith, 1996; Darlington & Smith, 1998; Matheson, Darlington & Smith, 1998).

The first trial was treated as a practice trial to ensure that the participant understood the instructions. Although the original intention was to average the CV latencies from the remaining 2 trials, it was clear that habituation had occurred even over 2 trials; therefore, the data from the 2nd trial were used as the best index of CV sensitivity following the practice trial but before habituation had occurred.

Results

Of 35 elderly participants, 3 (8.6%) were suspected to have a neurological disorder, which might involve a specific vestibular pathology, on the basis of their responses to the Questionnaire. These participants were advised to ask their GP for a referral to a neurologist. Five/thirty-five participants (14.3%) reported experiencing dizziness on more than one occasion over the past month. On the basis of their responses to the Questionnaire, this dizziness did not appear to be related to either a specific neurological disorder or to a cardiovascular problem; these participants considered themselves to be perfectly healthy and therefore it was possible that their dizziness was a result of age-related deterioration of the vestibular system. However, in the absence of any evidence of specific pathology, the data from all 8 participants with abnormal responses on the Questionnaire were pooled for comparison with elderly participants who did not complain of dizziness or any other vestibular symptom (ie. the non-dizzy comparison group).

The mean timeconstant for gaze-holding to the left in the 'dizzy' group was 24.5 ± 10.4 secs (n = 8), which was not significantly different from that for the comparison group (21.4 ± 12.4 secs, n = 27). However, the timeconstant for rightward gaze-holding was significantly shorter compared to the comparison group (6.1 ± 3.5 secs (n = 8) compared to 25.4 ± 9.9 secs (n = 27); $p < 0.0001$) (see Fig. 1).

The amount of postural instability, in terms of degrees of sway on the balance platform, ranged from 4 to 13° across the first 5 conditions of the CTSIB, and did not differ significantly between the dizzy group and the comparison group (see Fig. 2). However, in the 6th condition, the most difficult one in which the participant must stand on the balance platform on a foam surface wearing the visual-vestibular conflict dome, only 1/8 participants in the dizzy group could be tested because of the difficulty of the testing conditions; by comparison, 12/27 participants in the non-dizzy comparison group could be tested under these conditions. This result was supported by the data from the CTSIB test, in which the amount of time participants could maintain their balance under the 6 conditions was measured (see Fig. 3).

The latencies to Stage 2 and Stage 3 CV were 11.3 (± 3.9, n = 4) and 30.3 secs (± 12.5, n = 4), respectively, in the dizzy group, compared to 11.0 (± 3.9, n = 21) and 20.1 secs (± 10.2, n = 21) in the comparison group. Although the Stage 3 CV latencies for the dizzy group were higher, only 4 participants were able to complete this test because of their dizziness; statistical analysis was not performed because of the small sample size (see Fig. 4).

Discussion

The results of this study support the hypothesis that there is a high incidence of dizziness amongst the elderly. Excluding those participants who were suspected to have a specific neurological disorder, 14.3% of our sample of elderly participants reported experiencing dizziness. This percentage is substantially lower than the 30% reported by Colledge, Wilson, Macintyre and MacLennan (1994); however, since our study was directed at elderly people without a history of vestibular disorder, we were less likely to recruit dizzy participants. This result suggests that dizziness is a significant problem for elderly New Zealanders, and may increase the incidence of potentially life-threatening falls as well as psychological problems related to the fear of falling (Campbell, Robertson & Gardner, 1995).

Ocular motor testing using EOG indicated that, compared to the non-dizzy group, the dizzy participants showed normal gaze-holding to the left, but markedly abnormal gaze-holding to the right. In the latter case, the average timeconstant was approximately 75% lower than comparison values (see Fig. 1). Since the ability to maintain gaze in darkness at a particular point in visual space is a direct test of the integrity of the vestibulo-ocular and optokinetic ocular motor systems (Baloh & Honrubia, 1990), this result suggests that a significant age-related deterioration of the vestibular system may have developed in these participants. Since commissural interaction between the bilateral brainstem vestibular nuclei is critically important for the neural integration responsible for gaze-holding, the abnormal gaze-holding timeconstant could possibly be related to neuronal degeneration within the vestibular nucleus (Lopez, Honrubia & Baloh, 1997).

The posturography results did not reveal significant differences between the dizzy and non-dizzy participants, except in the 6th condition of the CTSIB, in which the participant must stand on the balance platform on a foam surface wearing the visual-vestibular conflict dome. In this condition, only 1/8 (12.5%) participants from the dizzy group could complete the test, compared to 12/27 (44%) participants from the comparison group. Maintenance of

Figure 1 Comparison of mean gaze-holding timeconstants (in secs) to the left and right in elderly dizzy and non-dizzy participants. Bars represent ± 1 S.D.

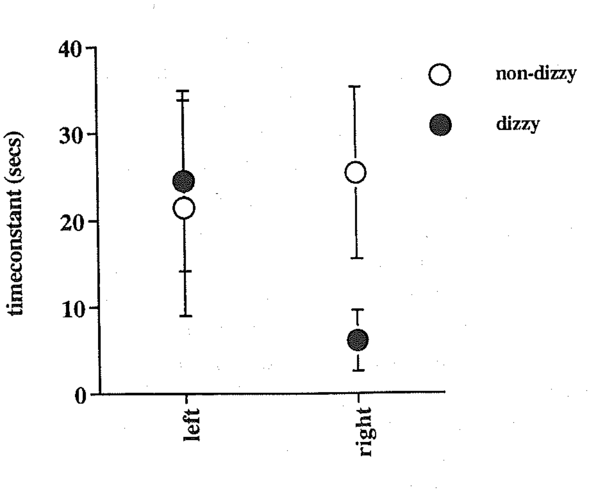


Figure 2 Comparison of mean postural sway (in degrees) in the first 5 conditions of the CTSIB (see Methods) for elderly dizzy and non-dizzy participants. Bars represent ± 1 S.D. Note that the 6th condition is excluded for the reasons described in the Methods.

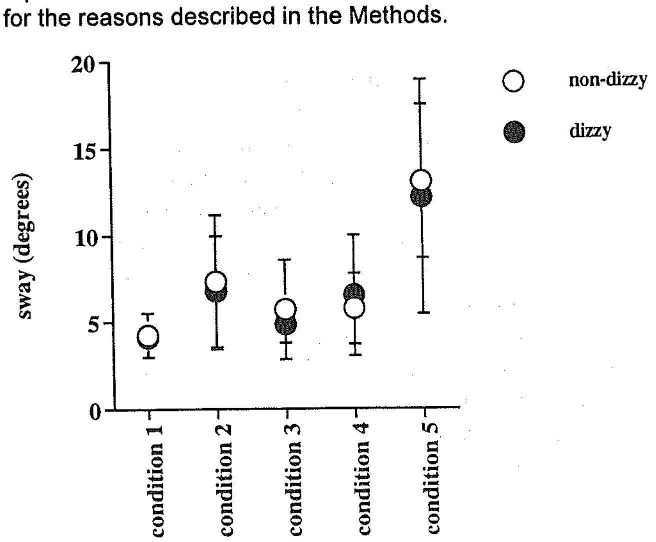


Figure 3 Comparison of mean time (in secs) spent on the balance platform (ie. up to a maximum of 30 secs) in the 6 conditions of the CTSIB for elderly dizzy and non-dizzy participants. Bars represent ± 1 S.D.

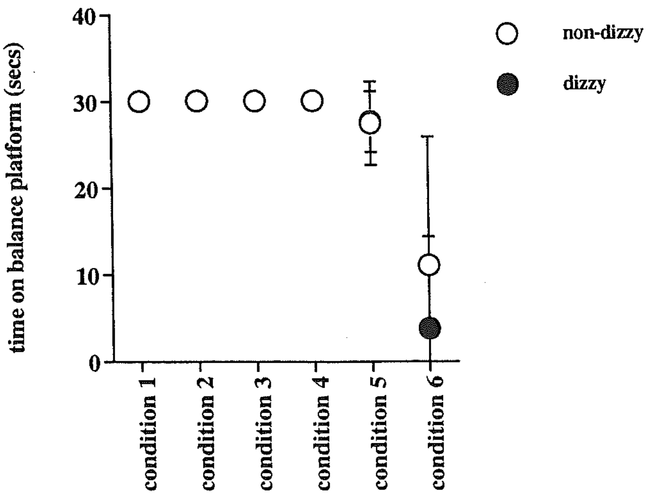
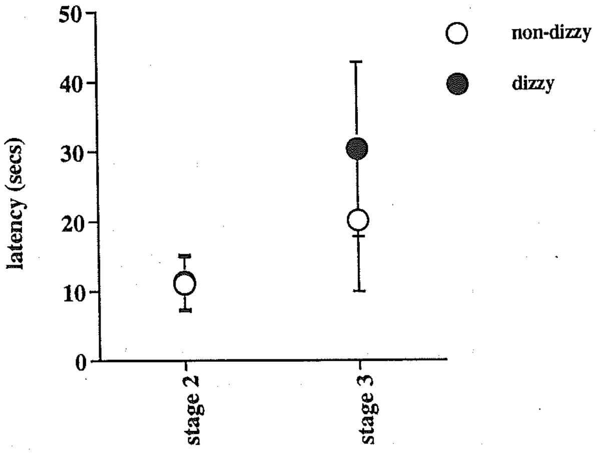


Figure 4 Comparison of mean latencies (in secs) to Stage 2 and Stage 3 circularvection (CV) for elderly dizzy and non-dizzy participants. Bars represent ± 1 S.D.



balance usually involves the integration of visual, vestibular, somatosensory and proprioceptive sensory inputs. However, performance in the 6th CTSIB condition requires the vestibular system to maintain balance under conditions in which the only visual information available is coupled to head movement (ie. the visual-vestibular conflict dome), and both proprioceptive and somatosensory cues are masked to a great extent by the use of the foam surface.

Unfortunately, the results of the optokinetic testing are difficult to interpret because of the small number of dizzy patients who could participate. Although the dizzy group showed higher Stage 3 CV latencies, suggesting reduced optokinetic sensitivity, this may be an artifact of the small sample size.

In conclusion, this study supports the view that dizziness is a significant problem for elderly people in New Zealand society and that it may be related to age-related deterioration of the vestibular system. It is important that this problem is recognised, since it is possible to reduce the impact of vestibular dysfunction and the incidence of falls through rehabilitation exercises (Campbell, Robertson & Gardner, 1995; Darlington & Smith, 1996b).

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Appendix 2

Behaviours used in the vignettes, taken from Sternberg's Scaling Solutions for Wise and Creative behaviours (Sternberg, 1985, Tables 4 and 5, pp. 615-616).

Wisdom

<u>Positive polarity: Reasoning ability.</u>
Has the unique ability to look at a problem or situation and solve it.
Has good problem-solving ability.
Has a logical mind.
Is good at distinguishing between correct and incorrect answers.
Is able to apply knowledge to particular problems.
Is able to put old information, theories, and so forth, together in a new way.

<u>Negative polarity: Sagacity.</u>
Displays concern for others.
Considers advice.
Understands people through dealing with a variety of people.
Feels he or she can always learn from other people.
Is thoughtful.
Is fair.

Creativity

<u>Positive polarity: Nonentrenchment.</u>
Makes up rules as he or she goes along.
Is impulsive.
Takes chances.
Tends not to know own limitations and tries to do what others think is impossible.
Is emotional.
Has a free spirit.

<u>Negative polarity: Integration and intellectuality.</u>
Makes connections and distinctions between ideas and things.
Has the ability to understand and interpret his or her environment.
Has the ability to recognise similarities and differences.
Is able to grasp abstract ideas and focus his or her attention on those ideas.
Is productive.
Has a high IQ level.

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