Visual Impairment and Falls in the Elderly: The Shihpai Eye Study

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Background: To investigate the association between visual impairment and falls in a metropolitan elderly Chinese population.

Methods: A population-based cross-sectional study of eye diseases among subjects 65 years of age and older was conducted in the Shihpai community of Taipei between July 1, 1999 and December 31, 2000.

Results: Of the 2,045 subjects invited, 1,361 (66.6%) participated in both the questionnaire and the eye examination. Sixty-two (4.6%; 95% confidence interval [CI], 3.4–5.7%) had experienced 2 or more falls in the previous 12 months. On univariate analysis, best-corrected Snellen visual acuity of the better eye less than 6/12 (odds ratio [OR], 2.47; 95% CI, 1.18–5.18; $p < 0.001$), female gender (OR, 2.52; 95% CI, 1.49–4.26; $p < 0.001$), high waist-to-hip ratio (OR, 1.86; 95% CI, 1.00–3.47; $p = 0.01$), history of diabetes mellitus (OR, 3.88; 95% CI, 2.27–6.62; $p < 0.001$) and cardiovascular disease (OR, 2.26; 95% CI, 1.34–3.80; $p = 0.04$) were significantly related to falls. In the final multiple logistic regression model controlling for other covariates, visual impairment (OR, 1.98; 95% CI, 1.02–4.32; $p < 0.001$), female gender (OR, 2.34; 95% CI, 1.29–4.23; $p < 0.01$), history of diabetes (OR, 3.61; 95% CI, 2.03–6.40; $p < 0.01$) and cardiovascular disease (OR, 1.96; 95% CI, 1.13–3.40; $p = 0.04$) were significantly related to falls.

Conclusion: Falls were significantly associated with a best-corrected Snellen visual acuity of less than 6/12. [*J Chin Med Assoc* 2008;71(9):467–472]

Key Words: Chinese, falls, metropolitan, population-based, visual impairment

Introduction

Falls become more frequent with age[1] and can cause injuries like hip fractures that may lead to functional decline, permanent disability, institutionalization or even mortality.[2] Approximately one third of older people living in the community have 1 or more falls every year.[3–5] The high incidence of injurious falls in the elderly has become a public health concern. Several studies have suggested that poor visual acuity,[6–9] impaired depth perception[10] and visual field impairment[11] are related to falls. The Framingham Study noted that poor vision or a difference in visual acuity between eyes was associated with an increased risk of fracture.[12] The EPIDOS study also found that reduced visual acuity was a risk factor for hip fractures.[13] A study conducted by the Longitudinal Aging Study Amsterdam identified that visual impairment, previous falls, urinary incontinence and use of benzodiazepines were the strongest predictors for any falls.[14] Similarly, visual impairment was strongly associated with 2 or more falls in the Blue Mountains Eye Study, which recruited subjects aged 49 years and older.[15] However, there are few population-based studies investigating the impact of poor visual acuity on falls in Asia.

The purpose of this study was to investigate the association between visual impairment and falls in a metropolitan elderly Chinese population.

Methods

The Shihpai Eye Study was a community-based cross-sectional survey of vision and common eye diseases of noninstitutionalized residents aged 65 years or older in the Shihpai community of Peitou District, Taipei,

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Taiwan. This study was approved by the Institutional Review Board of Taipei Veterans General Hospital and conducted according to the tenets of the Declaration of Helsinki of the World Medical Association regarding scientific research involving human subjects.

The baseline examination was conducted between July 1, 1999 and December 31, 2000. Details of sample selection and methods for the Shihpai Eye Study have been described previously.[16] In brief, 3,746 eligible residents aged 65 years or older were identified through the household registration system. This system officially registers personal information such as date of birth, sex and home address, as well as family members and relations.

According to the official household registration in 1999, the total number of residents aged 65 years and older in Shihpai was 4,750. Excluding vacant households (658 subjects), residents who had died before contact (48 subjects), and inpatient, paralyzed, and disabled residents (298 subjects), 3,746 persons were eligible, and 2,045 of them were randomly selected to be invited to participate in the study.

The study consisted of a structured questionnaire administered at home by intensively trained interviewers. The questionnaire was designed to cover information on demographic characteristics (sex, marital status, education level), family history, medical history (hypertension, diabetes mellitus, cardiovascular disease, and so on, previously diagnosed by a physician), and lifestyle (cigarette smoking, alcohol intake). During the home interview, subjects were asked, "During the past 12 months, did you have any falls that led you to land on the ground or floor?" If the answer was positive, they were then asked, "How many falls did you have in this period?" The place of falls, whether the falls led to any injury or fracture, and whether they were hospitalized or had received any treatment due to these falls were subsequently asked.

Subjects interviewed were invited to participate in a comprehensive standardized eye examination conducted in Taipei Veterans General Hospital which included automated refraction, presenting and best-corrected Snellen visual acuity, tonometry, slit-lamp biomicroscopy and indirect ophthalmoscopy. Ophthalmologists conducted the eye examination according to a standardized protocol. Informed consent was obtained from each subject before enrolment in the study.

Procedures

Visual acuity was assessed with a Snellen chart at a distance of 6 m and recorded separately for each eye. Presenting visual acuity was measured initially with the subject's glasses (if worn). Visual acuity was measured without glasses if the subjects did not have eyeglasses with them at the time of the ophthalmic examination (adults who did not wear eyeglasses or adults who had eyeglasses but did not wear them habitually).

If the presenting visual acuity was less than 6/6, the examination was repeated with subjective refraction. If the refraction measurement could not be appropriately obtained, a pinhole-corrected acuity test was performed. Visual acuity was determined as the smallest line in which most E's were positioned correctly; that is, 4 of 4 E's correct at a given level of acuity or at least 5 of 6 E's correct at a given level. Best-corrected distance visual acuity was defined as the best of all measurements.

Definitions

Falls were classified as significant if subjects experienced at least 2 falls in the past 12 months. Any pathological (primary or metastatic bone tumor-related) fall was excluded.

Waist girth was measured at the minimum circumference, while hip girth was measured at the maximum circumference. Regional or central obesity was defined as a waist-to-hip ratio ≥ 0.92 for men and ≥ 0.88 for women.[17]

Alcohol intake was limited to wine and hard alcohol. Beer consumption was not included as alcohol intake. Subjects were categorized as having the habit if alcohol consumption was more than once a week.

Statistical analysis

Analysis was performed for subjects with at least 2 falls in the last 12 months compared with subjects experiencing no falls during this period.

In this study, best-corrected Snellen visual acuity of the better eye was categorized into $<6/12$ and $\geq 6/12$, the cut-off for visual impairment that conformed to requirements for obtaining a driver's license in most states of the United States.[18]

Potentially confounding factors evaluated included sex (male *vs.* female), age (≥ 75 years *vs.* 65–74 years), waist-to-hip ratio (high: waist-to-hip ratio ≥ 0.92 for male; waist-to-hip ratio ≥ 0.88 for female *vs.* normal: waist-to-hip ratio < 0.92 for male; waist-to-hip ratio < 0.88 for female), alcohol use (yes *vs.* no), history of diabetes mellitus (yes *vs.* no), hypertension (yes *vs.* no) and cardiovascular disease (yes *vs.* no).

Independent variables assessed included best-corrected Snellen visual acuity with falls as a dependent variable. Odds ratios (ORs) and their 95% confidence intervals (CIs) were used to examine whether there was any statistically significant association between each of these independent variables and falls on univariate analysis.

Multiple logistic regression analysis was then used to fit the best model for independent variables and potentially confounding factors (covariates). Statistical analysis was performed using SAS version 6.12 (SAS Institute, Cary, NC, USA).

Results

Of the 2,045 subjects, 1,361 (66.6%) participated in both the questionnaire and eye examination. Six hundred and eighty-four subjects were not examined and, among them, 677 (33.1%) subjects cooperated only for the household interview and 7 (0.03%) subjects could not be contacted after 3 attempts to visit the household. Subjects who received eye examination were younger (72.2 years *vs.* 74.3 years, $p<0.001$), more likely to be male ($p<0.001$), and were more educated ($p<0.001$) than those who refused. There was no significant difference in the other variables (cigarette smoking, alcohol intake, history of diabetes and hypertension) between the 2 groups.

All of the 1,361 participants answered questions about falls. Among them, 214 (15.7%; 95% CI, 13.8–17.6%) reported at least 1 fall in the past 12 months and 62 (4.6%; 95% CI, 3.4–5.7%) reported 2 or more falls (Table 1).

The ORs and 95% CIs of potentially confounding factors for falls are shown in Table 2. Visual impairment was significantly related to falls (OR, 2.47; 95% CI, 1.18–5.18; $p<0.001$). Women (OR, 2.52; 95% CI, 1.49–4.26; $p<0.001$) were more likely to report falls than men. Having a higher waist-to-hip ratio (OR, 1.86; 95% CI, 1.00–3.47; $p=0.01$), a history of diabetes mellitus (OR, 3.88; 95% CI, 2.27–6.62; $p<0.001$), and cardiovascular disease (OR, 2.26; 95% CI, 1.34–3.80; $p=0.04$) were also significantly associated with falls.

On multiple logistic regression analysis, best-corrected Snellen visual acuity of less than 6/12 in the better eye (OR, 1.98; 95% CI, 1.02–4.32; $p<0.001$) was significantly related to falls. Moreover, female gender (OR, 2.34; 95% CI, 1.29–4.23; $p<0.01$), history of diabetes (OR, 3.61; 95% CI, 2.03–6.40; $p<0.01$) and history of cardiovascular disease (OR, 1.96; 95% CI, 1.13–3.40; $p=0.04$) were associated with falls in the previous 12 months (Table 3).

Discussion

Visual deficit has been suggested as a risk factor for falling in adults.[14,15] However, few studies have focused on the relationship between visual impairment and falls in the very elderly (≥65 years old), especially in Asian countries.

Our results are in line with the findings of the Framingham study.[12] In their survey, poor and moderately impaired vision increased the risk of hip fracture in women. Although their study evaluated the risk of hip fracture rather than falling, it has been shown that 90% of hip fractures in elderly people result from a fall.[13]

In the Blue Mountains Eye Study of noninstitutionalized residents, 29.6% of those 65 years of age and older reported ≥1 falls in the previous 12 months, which was much higher than among the participants in this study (15.7%). In their 2-year follow-up, corrected visual acuity worse than 20/60 was associated with hip fracture.[15,19] The great difference in fall prevalence between the 2 studies may be due to racial and geographical differences. Besides, control of balance is dependent on accurate sensory inputs from vestibular, tactile, proprioceptive and visual systems, central processing, and motor response.[13] Disruption of any of these mechanisms may lead to a fall. Whether or not factors besides vision (for example, better proprioceptive abilities in our population) contributed to the difference in fall prevalence deserves further investigation.

Opinions vary on whether visual acuity is associated with falls. In the Beaver Dam Eye Study of subjects

Table 1. Prevalence of falls in the past year by age and sex in Shihpai, Taipei, Taiwan, 1999–2000

Age (yr)	Male			Female			Total		
	Fall history in the past year			Fall history in the past year			Fall history in the past year		
	Examined, *n*	≥2 falls, *n*	Prevalence, %	Examined, *n*	≥2 falls, *n*	Prevalence, %	Examined, *n*	≥2 falls, *n*	Prevalence, %
65–69	289	10	3.5	198	14	7.1	487	24	49
70–74	314	5	1.6	177	12	6.8	491	17	3.5
≥75	219	9	4.1	164	12	7.3	383	21	5.5
Total	822	24	2.9	539	38	7.1	1,361	62	4.6

Table 2. Univariate analysis of factors contributing to falls in Shihpai, Taipei, Taiwan, 1999–2000

	Fall history ≥ 2 in the past year		*p*	OR	95% CI
	Yes (*n* = 62)	No (*n* = 1,299)			
Sex			< 0.001	2.52*	1.49–4.26
Female	38 (61.3)	501 (38.6)			
Male	24 (38.7)	798 (61.4)			
Age (yr)			0.75	1.33	0.78–2.29
≥ 75	21 (33.9)	361 (27.8)			
65–74	41 (66.1)	938 (72.2)			
Visual impairment			< 0.001	2.47*	1.18–5.18
BCVA < 6/12	9 (14.5)	90 (7.1)			
BCVA ≥ 6/12	53 (85.5)	1,178 (92.9)			
Waist-to-hip ratio			0.01	1.86*	1.00–3.47
High†	49 (79.0)	869 (66.9)			
Normal	13 (21.0)	430 (33.1)			
Alcohol use			0.46	0.60	0.27–1.34
Yes	7 (11.3)	227 (17.5)			
No	55 (88.7)	1,072 (82.5)			
History of hypertension			0.31	1.53	0.92–2.55
Yes	34 (54.8)	575 (44.3)			
No	28 (45.2)	724 (55.7)			
History of diabetes			< 0.001	3.88*	2.27–6.62
Yes	24 (38.7)	182 (14.0)			
No	38 (61.3)	1,117 (86.0)			
History of cardiovascular disease			0.04	2.26*	1.34–3.80
Yes	21 (36.8)	315 (32.0)			
No	36 (63.2)	984 (75.8)			
History of stroke			0.66	1.40	0.49–3.98
Yes	4 (6.5)	61 (4.7)			
No	58 (93.5)	1,238 (95.3)			
History of arthritis			0.67	1.65	0.88–3.10
Yes	13 (21.0)	180 (13.9)			
No	49 (79.0)	1,119 (86.1)			

**p < 0.05; †male waist-to-hip ratio ≥ 0.92 and female waist-to-hip ratio ≥ 0.88. OR = odds ratio; CI = confidence interval; BCVA = best-corrected visual acuity.*

Table 3. Multiple logistic regression analysis of best-corrected visual acuity for falls in the past year in Shihpai, Taipei, Taiwan, 1999–2000*

	p	OR	95% CI
Sex (female *vs.* male)	< 0.01	2.34†	1.29–4.23
Age (≥ 75 yr *vs.* 65–74 yr)	0.85	1.11	0.63–1.96
BCVA (< 6/12 *vs.* ≥ 6/12)	< 0.001	1.98†	1.02–4.32
Waist-to-hip ratio (high *vs.* normal)	0.83	1.21	0.63–2.33
Alcohol use (yes *vs.* no)	0.56	0.87	0.36–2.11
History of hypertension (yes *vs.* no)	0.67	1.02	0.59–1.79
History of diabetes (yes *vs.* no)	< 0.01	3.61†	2.03–6.40
History of cardiovascular disease (yes *vs.* no)	0.04	1.96†	1.13–3.40
History of stroke (yes *vs.* no)	0.56	1.00	0.33–3.06
History of arthritis (yes *vs.* no)	0.67	1.59	0.82–3.08

**Adjusted variables included sex, age, waist-to-hip ratio, alcohol use, and history of diabetes/hypertension/cardiovascular disease/stroke/arthritis; †p < 0.05.*

43–84 years of age, 6.2% of 3,722 subjects reported falling more than once in the year prior to the examination. For persons older than 60 years of age, those who were classified as having poorer best-corrected acuity (20/25 or worse) were more likely to have had ≥2 falls.[20] Ivers's Auckland Hip Fracture Study (subjects ≥ 60 years old) found that poor visual acuity alone had an attributable risk of 15% for hip fracture.[21] The EPIDOS study, which recruited women aged ≥75 years (mean age, 80.5 years), also found that reduced visual acuity was an independent predictor of hip fractures.[13]

In contrast, Cummings et al found that poor depth perception and contrast sensitivity were associated with an increased risk of hip fracture in white women (mean age, 72.0 years) but impaired visual acuity was not.[22]

As opposed to the EPIDOS view that the difference between their findings and Cummings et al was due to a difference in the mean age of the study groups (80.5 *vs.* 72.0), this study had a similar age group as in the study of Cummings et al (72.2 *vs.* 72.0), and we did find that visual acuity was associated with falls. This result implies that visual acuity is an important factor that is associated with falls in both the elderly and very elderly groups.

These data suggested that visual impairment was associated with falls in the past 12 months and was mainly due to a decrease in visual acuity that may lead to inaccurate assessment of environmental obstacles or configuration and impairment of postural stability, mobility and physical function and hence increase the risk of falling.[13,23,24]

There were some limitations in this study, however. First, the unexamined subjects were older and more likely to be female, in whom falls and hip fractures occur more frequently.[1] Second, the number of falls in the past 12 months was obtained retrospectively, which made it susceptible to recall bias. Third, visual acuity was evaluated after falling and may not truly reflect the visual acuity at the time of the falls. However, it has been shown that vision in a population is stable over a 5-year period in those younger than 75 years.[25] On the other hand, this study population comprised noninstitutionalized survivors, and this, combined with the first 2 factors, likely led to an underestimation of fall prevalence. In other words, the association between visual acuity and falls should be stronger than our results showed.

Another important limitation of this study is that other aspects of visual function like visual field, contrast sensitivity, stereopsis and color sensation, which could have affected falling, were not measured. The Beaver Dam Eye Study found that previous hip fracture was associated with measures of visual function such as visual acuity, contrast sensitivity, and visual sensitivity.[20] Elderly with multiple falls had decreased vision, including impaired depth perception and contrast sensitivity, with low low-contrast visual acuity being the strongest risk factor.[25] In the Auckland Hip Fracture Study, absence of gross stereopsis had a population-attributable risk of 35%.[21] On the other hand, visual field loss was also identified as a risk factor for falls in the elderly in the Blue Mountains Eye Study[15] and by Glynn et al.[11]

Despite this, our findings suggest that a substantial proportion of falls are visual acuity-related and could be prevented through public education about the impotance of regular ophthalmic examination.

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