

The Effect of an Individualized Fall Prevention Program on Fall Risk and Falls in Older People: A Randomized, Controlled Trial

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OBJECTIVES: To determine whether an individualized falls prevention program comprising exercise, visual, and counseling interventions can reduce physiological falls risk and falls in older people.

DESIGN: Randomized, controlled trial of 12 months' duration.

SETTING: Falls Clinic, Royal North Shore Hospital, Sydney, Australia.

PARTICIPANTS: Six hundred twenty people aged 75 and older recruited from a health insurance company membership database.

INTERVENTIONS: Participants in the extensive intervention group (EIG) received individualized interventions comprising exercise and strategies for maximizing vision and sensation; the minimal intervention group (MIG) received brief advice; and the control group (CG) received no intervention.

MEASUREMENTS: Accidental falls, vision, postural sway, coordinated stability, reaction time, lower limb muscle strength, sit-to-stand performance, and physiological profile assessment (PPA) falls risk scores.

RESULTS: At the 6-month follow-up, PPA falls risk scores were significantly lower in the EIG than in the CG. EIG subjects assigned to the extensive exercise intervention group showed significant improvements in tests of knee flexion strength and sit-to-stand times but no improvements in balance. EIG subjects assigned to the extensive visual intervention group showed significant improvements in tests of visual acuity and contrast sensitivity. The rate of falls and injurious falls within the trial period were similar in the three groups.

CONCLUSION: The individualized intervention program reduced some falls risk factors but did not prevent falls. The lack of an effect on falls may reflect insufficient targeting of the intervention to an at-risk group. *J Am Geriatr Soc* 53:1296–1304, 2005.

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Studies assessing efficacy of interventions to prevent falls have comprised single-risk-factor and multifactorial approaches. Intervention strategies in single-risk-factor studies have included exercise to promote strength and balance,^{1–10} interventions to optimize vision,⁹ provision of pacemakers to prevent drop attacks,¹¹ environmental modifications to promote safety in the home,^{9,12,13} and strategies for reducing hazardous medication use.¹⁴ For each intervention strategy, it appears that interventions are most successful when targeted to groups most at risk.

The second approach has involved interventions that are of a multifactorial nature in that they have targeted their prevention strategies to identified and often multiple risk factors.^{15–18} As with single interventions, multifactorial interventions are most effective when targeted to an older person's individual impairments and situation.^{15,16,19}

In previous studies a range of physiological risk factors for falls in older people living in the community have been identified.^{20,21} These studies have shown that impairments of vision, peripheral sensation, muscle strength, reaction time, and balance singly and cumulatively increase the risk of falls in these groups. Based on these findings, a physiological profile assessment (PPA) was developed that calculates an overall falls risk score and compares an individual's performance on each physiological test with normative values to identify specific deficits.²²

The PPA may therefore provide a useful instrument for identifying appropriate interventions because it assesses functional performance in the primary physiological domains necessary for maintaining stability.²² In this study, PPA test results were used to implement individualized interventions for preventing falls in a large sample of older people. A secondary aim was to assess whether a minimal intervention comprising brief advice based on the PPA would also constitute an effective intervention.

METHODS

Subjects and Recruitment

The study population consisted of community-dwelling people aged 75 and older living in northern Sydney, Australia. Participants were randomly drawn from a health insurance company membership database. Subjects were excluded from the study if they had minimal English language skills, were blind, or had Parkinson's disease or a Short Portable Mental Status Questionnaire score less than 7.²³ Transport was provided for those who could not make their own way to the falls assessment clinic to maximize participation rates of older people with mobility limitations. Of the 2,468 subjects initially contacted, 700 (28%) agreed to participate, and of these, 684 (238 men, 446 women) aged 75 to 98 (mean \pm standard deviation 80.4 ± 4.5) met the inclusion criteria and underwent the PPA risk assessment. After this assessment, a further 64 subjects (27 men, 37 women) were excluded because they performed well on each PPA test (i.e., had z scores > -1). These subjects were considered not to be at an increased risk of falls.

Figure 1 shows the recruitment process. The subjects were randomized in matched blocks ($n = 20$) into one of the three intervention groups after the baseline assessment, using concealed allocation (drawing lots). The groups received the individualized interventions (extensive intervention group (EIG)), brief advice (minimal intervention group (MIG)), or no intervention (control group (CG)). The human studies ethics committee at the University of New South Wales gave approval for this study, and informed consent was obtained from all subjects before their participation.

The PPA Assessment

Investigators blind to treatment allocation assessed the subjects at baseline and at 6 months. The PPA and sit-to-stand (STS) performance measures were selected because they have been identified as important falls risk factors in previous studies^{20–22} and because they are measures that the interventions may influence. The PPA uses a Web-based computer software program²⁴ to assess a participant's performance in relation to a normative database compiled from population studies.^{20,21} This program produces a falls risk assessment report for each individual that includes a graph indicating an participant's overall falls risk score, a profile of the participant's test performances, and written recommendations for improving functional performances and compensating for any impairments identified.

Figure 2 shows a test performance profile graph. This graph presents test results in standardized (z) scores form, using the reference data from the population studies. Thus, a score of 0 indicates average performance for people aged 65 and older, positive scores indicate above-average performances, and negative scores indicate below-average performances. Each unit represents one standard deviation.

The individual PPA test measures have been described in detail previously, and test-retest reliability for these measures has been established in groups similar to the current study population.²² High- and low-contrast visual

acuity were assessed using a logMAR chart at a test distance of 3 m.²² Edge-contrast sensitivity was assessed using the Melbourne Edge Test²⁴ with subjects wearing their near-vision lens correction as appropriate. Depth perception was measured using a Howard-Dohlman depth perception apparatus.²⁶ Peripheral sensation was assessed with tests of proprioception, tactile sensation, and vibration. Proprioception was measured using a lower limb-matching task.²² Errors were recorded using a protractor inscribed on a vertical clear acrylic sheet (60 cm \times 60 cm \times 1 cm) placed between the legs. Tactile sensitivity was measured at the lateral malleolus using a Semmes-Weinstein aesthesiometer.²² Vibration sense at the tibial tuberosity of the knee was measured using a vibrator that produced a 200-Hz vibration of varying intensity under load.²² The average maximal voluntary strength of the knee extensor, knee flexor, and ankle dorsiflexor muscle groups in the subjects' dominant (stronger) leg was measured under isometric conditions in a seated position.²² Simple reaction time was assessed in ms with subjects seated using a light as the stimulus and a finger press and a foot press as the response.²² Subjects had five practice trials and 10 test trials; the average of the 10 test trials was the test measure. Postural sway was measured using a swaymeter that measured displacement of the body at the level of the waist.²² Testing was performed with subjects standing on the floor and on a foam rubber mat (60 cm \times 60 cm \times 15 cm thick) with eyes open and eyes closed. Leaning balance was assessed using the coordinated stability test, a balance test that requires subjects to adjust their balance in a steady and coordinated manner when near the limits of their base of support.²⁷

STS performance was also assessed because it is has been demonstrated to be a good measure of functional performance and a predictor of falls.²⁸ STS performance was measured by asking subjects to rise from a 45-cm-high chair five times as fast as possible with their arms folded.²⁹

Self-Rated Health and Activity Levels

The Short-Form 12 Health Status Questionnaire was used to provide validated assessments of physical and mental health.³⁰ The subjects completed structured interviews relating to medical conditions, medication use, falls history, mobility and activity limitations, planned walks, exercise, and activity levels.

The Interventions

The EIG

The extensive intervention comprised the PPA report outlining falls risk, a profile of test results, and specific written recommendations for preventing falls. Subjects allocated to this intervention also received a counseling session after the assessment, at which the report and recommendations were explained. If subjects had one or more PPA strength, reaction time, or balance standardized (z) test scores less than -1 , they received individualized exercises aimed at improving strength, coordination, and balance. If subjects had one or more PPA vision standardized test scores less than -1 , they received interventions for maximizing vision, including referral to an eye specialist, change in spectacles, and cataract surgery. Finally, if subjects had one or more PPA peripheral sensation standardized test scores less than

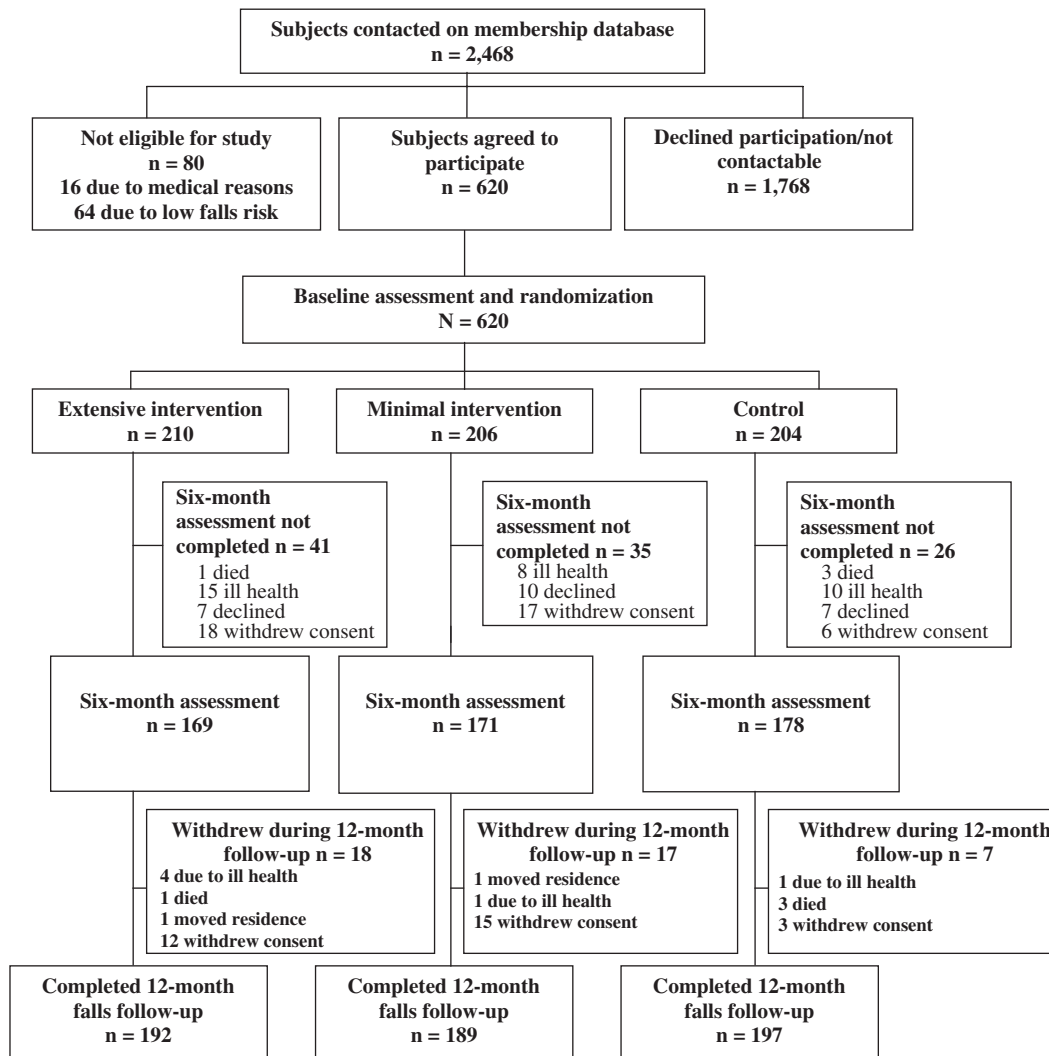


Figure 1. Flow chart outlining number of participants in each study arm.

– 1, they received a counseling intervention concerned with strategies to compensate for reduced peripheral sensation. Brief descriptions of the interventions follow.

The Individualized Exercise Intervention: The exercise classes were conducted twice weekly over a 12-month period at eight sites in northern Sydney. This program was conducted in four 10- to 12-week terms with 2-week inter-term breaks and a 5-week summer vacation break. Five accredited fitness instructors trained to provide the same program led the classes (with one instructor assigned to an exercise venue and exercise session). The number of participants in each exercise class ranged from 9 to 15 (average = 11).

The classes comprised a 5- to 10-minute warm-up, a 30-minute conditioning component done as a group, a 10-minute individualized program component and a 5- to 10-minute cool-down. The group conditioning component included exercises aimed at improving strength, flexibility, coordination, and balance. The individualized exercise regimes were based on the subjects' falls risk profiles. Subjects with muscle weakness in specific muscle groups received specific exercises to improve their strength; those with poor balance received standing, leaning, and stepping balance

training; and those who performed poorly in the reaction time tests received exercises that challenged speed and coordination. Specific strengthening exercises included seated resistance training, chair-assisted knee bends, wall squats, heel raises, and STS practice. Balance and reaction time and coordination exercises included choice stepping reaction time tasks, ball throw and catch, controlled leaning balance using a swaymeter,²⁷ step ups onto and over a block, and walking on uneven surfaces.

For each exercise, an initial target number of eight repetitions was selected, and this was then increased using the Borg³¹ perceived scale of exertion and using strength training progressions according to the American College of Sports Medicine guidelines.³² Exercise intensity was also increased through the use of weighted ankle cuffs, weight belts, and elastic resistance bands. Individual progression was documented using exercise diaries, which included the number of repetitions completed and the exercise intensity.

The Visual Intervention: The visual intervention involved referral to an eye care specialist if participants had not had an eye examination in the previous 6 months. The interventions included new glasses as required, use of

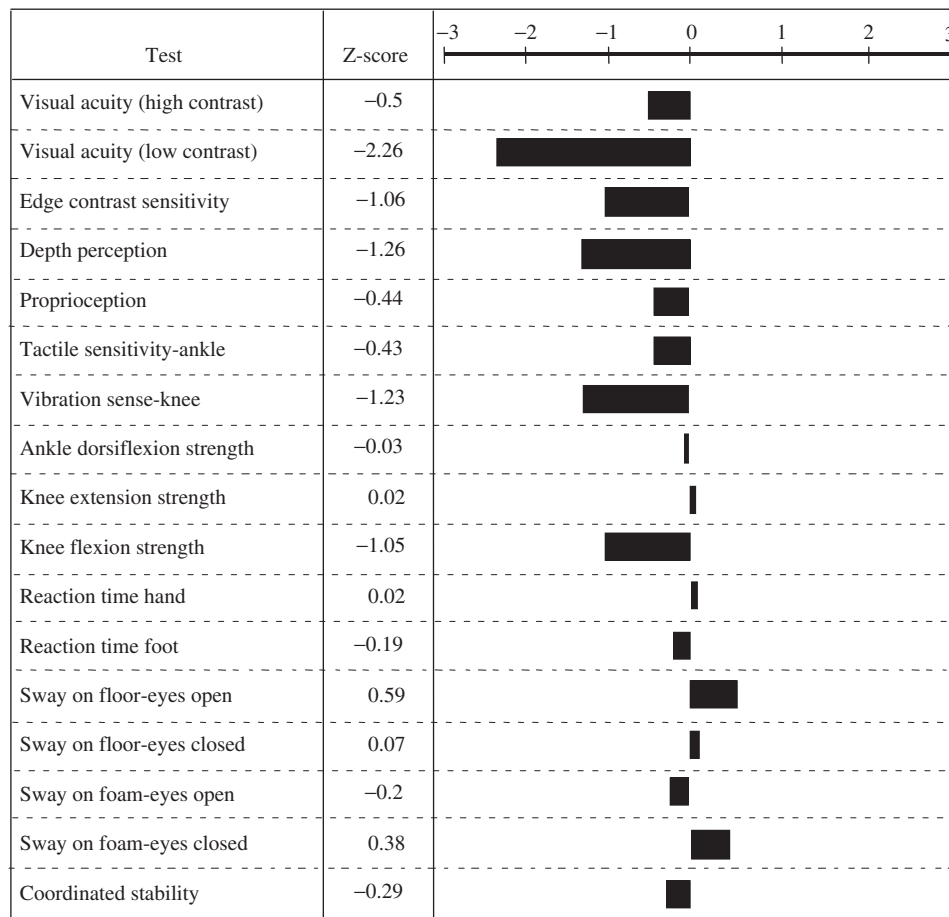


Figure 2. Example of a subject’s test performance profile graph.

single lens spectacles when walking outside the home, and cataract surgery if indicated. A demonstration of the effects of multifocal glasses on distance edge contrast sensitivity was included in a counseling session, and a rationale for not wearing multifocal glasses when walking outside the home was provided.³³ The subjects also received written advice about how to maximize their vision, including wearing spectacles at all times when ambulating, wearing a hat and sunglasses to reduce glare in bright sunshine, taking care when walking outside at night or at dusk, and ensuring that lights are on when walking in the home at night.

The Peripheral Sensation Counseling Intervention: This intervention involved counseling about the role that reduced lower limb sensation plays in impaired stability. Subjects were advised to take the following precautions: take particular care when walking on irregular or soft surfaces such as uneven ground and thick carpets, use a walking stick or a sturdy umbrella as a sensor to compensate for sensation loss, wear shoes with low heels and firm rubber soles to maximize balance, and have an assessment with their primary care physician to assess whether any medical condition, such as diabetes mellitus, could be leading to the sensory loss.

The MIG

Subjects allocated to the MIG received the report outlining their falls risk, a profile of their test results, and specific recommendations for preventing falls based on their test

performances. Subjects with poor strength, reaction time, and balance scores were given instruction sheets for home exercises and undertook a brief training session to ensure that they could undertake the exercises correctly. In addition, these subjects were provided with a list of group exercise programs that were available near their homes. These subjects also received written advice about how to maximize their vision and about precautions to take for loss of peripheral sensation where applicable. The minimal intervention was included as an intervention arm because identification of lower-cost interventions is important in healthcare settings with limited resources.

The Control Group

The CG received no intervention. At the end of the 12-month trial, these participants received the report outlining their falls risk, a profile of test results, and specific recommendations for preventing falls based on these performances (i.e., the minimal intervention).

Intervention Effects and Compliance

The PPA and STS tests were reassessed at 6 months—a sufficient period to detect any beneficial effects of an exercise program³⁴ and for all visual interventions to be implemented. Self-reported subject compliance with each of the interventions recommended at baseline was also documented at this time. For subjects eligible for the exercise intervention

in the EIG, compliance was measured by recording exercise class attendance and diary records for home exercises.

Falls Surveillance

Falls were defined as “events that resulted in a person coming to rest unintentionally on the ground or other lower level, not as the result of a major intrinsic event or an overwhelming hazard.”³⁵ Injurious falls were defined as falls that resulted in bruises, strains, cuts and abrasions, back pain, and fractures. Falls were monitored for 1 year using monthly fall calendars. When a fall occurred, specific details about fall injuries were obtained from telephone interviews. If falls calendars were not returned at the end of each month, further contact was made by telephone interview.

Statistical Analysis

The data were analyzed on an intention-to-treat basis, using SPSS (SPSS Corp., Chicago, IL) and Stata 7 (Stata Corp., College Station, TX) statistical software. The continuous physical performance scores at the 6-month follow-up were compared by forced entry multiple linear regression analysis, with baseline scores and experimental group included as independent variables in the models. The number of falls in the three groups was compared by calculating incidence ratio rates using negative binomial regression models, adjusting for baseline differences in fall rates and incomplete follow-up in a small percentage of subjects. Negative binomial regression models take into account not only all falls during the trial, but also the distribution of falls, which is exponential-like but with overdispersion, that is, contains a wider, higher tail in the distribution.³⁶

RESULTS

Demographic, Health, and Lifestyle Characteristics at Baseline

Table 1 shows the baseline demographic, health, and physical activity characteristics of the EIG, MIG, and CG. The groups were similar in all measures with the exception that the EIG had suffered more falls in the previous year and were more fearful of falling. There were no statistically significant differences between the groups for baseline STS and PPA individual and fall risk index scores.

Intervention Compliance and Subject Retention

Of the total sample, 423 subjects (68.2%) were eligible for the exercise intervention, 427 subjects (68.9%) were eligible for the vision intervention and 192 subjects (31.0%) were eligible for the sensation intervention. The proportions of eligible subjects in the three groups were similar. Compliance with individual recommendations ranged from low to high. The average number of exercise classes offered to the 153 subjects in the EIG was 78 (range 67–90). The median number attended was 21 (range 0–82). Twenty people (13.1%) in the EIG who could not undertake or complete the group exercises participated in a partially supervised home exercise program. Of these people, 18 (90%) performed the exercises twice weekly, and two (10%) performed the exercises once per week.

Compliance with the visual interventions (visit an eye specialist, wear hat/sunglasses in high-glare situations, and

turn a light on at night when walking in the home) ranged between 67% and 68% for the EIG and 53% and 77% for the MIG. Compliance with the recommendation for avoiding multifocal glasses was lower: 30% in the EIG and 11% in the MIG. Compliance with the sensation interventions (wear safe shoes, visit a medical practitioner, and turn a light on at night when walking in the home) ranged between 46% and 75% for the EIG and 36% and 76% for the MIG. For each measure, the majority of subjects indicated that they had adopted the suggested behaviors as a result of the recommendations (i.e., they were not already practicing them).

Figure 1 shows the number of participants in the treatment arms at each stage of the study; 518 subjects completed the 6-month PPA assessments, and 578 subjects (93.2%) completed the 12-month falls follow-up (mean number of diaries completed \pm standard deviation = 11.2 ± 2.3).

Physical Functioning Outcomes in the Intervention Subjects Assigned to the Exercise Program

Table 2 shows the baseline and 6-month scores for the PPA and STS measures for the subjects in each group who were eligible for an exercise intervention (Table 2). There were significant differences between the groups for knee flexion strength and STS times at 6 months. Post hoc testing indicated that those in the EIG and MIG had quicker STS times than those in the CG in the STS test and those in the EIG had significantly greater knee flexion strength compared with the CG. The groups did not differ on the remaining strength, reaction time, and balance tests.

Vision Outcomes in the Intervention Subjects Assigned to the Visual Interventions

Table 3 shows the baseline and 6-month scores for the PPA visual tests for the subjects in each group who were eligible for the visual intervention. There were significant differences between the groups for the high- and low-contrast visual acuity and contrast sensitivity tests at 6 months. Post hoc testing indicated that those in the EIG and MIG had significantly better visual acuity than those in the CG and that those in the EIG had significantly better contrast sensitivity than those in the CG.

Fall Risk and Falls

PPA falls risk scores were reduced to the greatest extent in the EIG (-0.242 ± 0.766), to an intermediate degree in the MIG (-0.198 ± 0.965), and only by a small amount in the CG (-0.118 ± 0.761) ($t = -1.98, P < .05$). Post hoc testing indicated that the difference in falls risk scores between the EIG and CG was statistically significant ($t = 21.08, P < .05$).

Fall rates and the number and proportion of subjects in each treatment arm who reported falls and falls injuries within the trial period are shown in Table 4. It is likely that the relatively high proportion of injurious falls was due to the inclusion of falls that caused minor injuries. When adjusting for previous falls, the fall rates in the EIG and MIG were not significantly different from that of the CG. This was also reflected in similar fall rates within subjects in the EIG, MIG, and CG who suffered injurious falls. Although

Table 1. Prevalence of Major Medical Conditions, Medication Use, Participation in Physical Activity, and Mobility and Activity of Daily Living (ADL) Limitations in the Study Population at Baseline

Variable	Extensive Intervention Group (n = 210)	Minimal Intervention Group (n = 206)	Control Group (n = 204)	Total (N = 620)
Demographic factors				
Female, n (%)	140 (66.7)	128 (62.1)	141 (69.1)	409 (66.0)
Age, mean \pm SD	80.3 \pm 4.3	80.7 \pm 4.6	80.2 \pm 4.6	80.4 \pm 4.5
Health and medical conditions				
Perceived health status (fair or poor)*, n (%)	27 (12.8)	16 (7.8)	14 (6.9)	57 (9.2)
SF12 physical, mean \pm SD	47.5 \pm 9.1	48.2 \pm 8.6	47.9 \pm 9.3	47.9 \pm 9.0
SF12 emotional, mean \pm SD	55.3 \pm 6.6	55.4 \pm 6.9	55.9 \pm 6.7	55.6 \pm 6.7
Pain in last week, n (%)	45 (21.4)	36 (17.7)	36 (17.7)	117 (19.0)
Previous stroke, n (%)	17 (8.1)	16 (7.8)	15 (7.4)	48 (7.7)
Giddy on standing, n (%)	97 (47.1)	95 (47.3)	101 (50.5)	293 (48.3)
Arthritis, n (%)*	103 (49.0)	86 (41.7)	78 (38.2)	267 (43.1)
Diabetes mellitus, n (%)	16 (7.6)	12 (5.8)	16 (7.8)	44 (7.1)
Incontinence, n (%)	40 (19)	25 (12.1)	36 (17.6)	101 (16.3)
Depression, n (%)	21 (10)	24 (11.7)	18 (8.8)	63 (10.2)
Medication use, n (%)				
Musculoskeletal medications	58 (27.6)	45 (21.8)	49 (24)	152 (24.5)
Cardiovascular medications	147 (70.0)	139 (67.5)	153 (75.0)	439 (70.8)
Psychoactive medications	35 (16.7)	38 (18.4)	25 (12.3)	98 (15.8)
Four plus medications	112 (53.3)	102 (49.5)	97 (47.5)	311 (50.2)
Physical activity, n (%)				
≥ 1 planned walks/wk	117 (55.7)	108 (52.4)	112 (54.9)	337 (54.4)
Participates in planned sports	58 (27.8)	56 (27.2)	53 (26.0)	167 (27.0)
Incidental physical activity > 2 hr/d	93 (44.3)	79 (38.3)	81 (39.7)	253 (40.8)
Total activity > 3 hr/d	65 (31.1)	52 (25.2)	53 (26.0)	170 (27.5)
Mobility and ADL limitations				
Previous falls, mean \pm SD [†]	0.85 \pm 1.53	0.62 \pm 0.92	0.73 \pm 0.11	0.72 \pm 1.21
Injurious falls in past year, n (%)	70 (33.3)	54 (26.2)	60 (29.4)	184 (29.7)
Fearful of falling (moderate or more), n (%) [†]	69 (33.3)	46 (22.4)	63 (31.2)	178 (29.0)
Used a walking aid, n (%)	43 (20.5)	28 (13.6)	44 (21.6)	115 (18.5)
Difficulty shopping, n (%)	35 (16.7)	29 (14.1)	35 (17.2)	99 (16)
Difficulty with housework, n (%)	70 (33.3)	64 (31.2)	79 (38.9)	213 (34.5)
Difficulty with home maintenance, n (%)	136 (65.1)	117 (57.1)	135 (66.5)	388 (62.9)
Difficulty cooking, n (%)	37 (17.6)	33 (16.1)	28 (13.9)	98 (15.9)
Difficulty dressing, n (%)	7 (3.3)	4 (2.0)	5 (2.5)	16 (2.6)

Note: Differences between groups assessed using analysis of variance, negative binomial regression, and chi-square tests for cross-tabulation tables.

* $P < .1$; [†] .05.

SD = standard deviation; SF12 = 12-item Short Form.

Table 2. Baseline and 6-Month Scores for Tests Relevant to the Exercise Intervention

Test Variable	EIG (n = 118)		MIG (n = 109)		CG (n = 116)	
	Baseline	6-Month	Baseline	6-Month	Baseline	6-Month
	Mean ± Standard Deviation					
Strength (kg force)						
Ankle dorsiflexion	5.7 ± 3.0	5.6 ± 3.4	5.9 ± 2.8	5.6 ± 3.1	5.4 ± 3.4	5.6 ± 3.4
Knee extension	23.5 ± 11.9	24.3 ± 12.0	24.0 ± 10.7	24.0 ± 11.3	23.9 ± 10.2	23.4 ± 10.8
Knee flexion	13.2 ± 5.5	13.9 ± 6.1 [†]	13.3 ± 5.4	13.5 ± 5.8	13.0 ± 5.2	12.6 ± 5.9
Reaction time (ms)						
Finger press	287 ± 44	267 ± 44	295 ± 62	262 ± 37	288 ± 55	267 ± 45
Foot press	368 ± 74	333 ± 58	377 ± 66	338 ± 60	376 ± 62	337 ± 56
Balance and transfers						
Sway						
Eyes open—floor*	519 ± 534	475 ± 481	502 ± 408	459 ± 364	480 ± 516	516 ± 595
Eyes closed—floor*	699 ± 760	690 ± 719	597 ± 520	608 ± 607	694 ± 812	653 ± 1020
Eyes open—foam*	1,598 ± 953	1,495 ± 1,019	1,673 ± 1,184	1,632 ± 1,350	1,690 ± 1,187	1,661 ± 1,313
Eyes closed—foam*	3,936 ± 2,534	3,374 ± 2,319	3,913 ± 2,293	3,392 ± 2,546	3,787 ± 2,398	3,539 ± 2,180
Coordinated stability (error score)	9.8 ± 8.7	8.6 ± 8.0	10.8 ± 9.1	10.5 ± 8.8	9.8 ± 8.4	10.3 ± 9.0
Sit-to-stand time, seconds	13.7 ± 6.4	11.7 ± 4.6 [‡]	13.4 ± 5.5	12.1 ± 5.2*	14.1 ± 6.1	13.7 ± 6.2

* Product of maximal sagittal and lateral sway in 30-second trials (mm²).

Overall F statistics indicated significant differences between the groups for knee flexion strength and sit-to-stand times ($p < 0.05$). Post hoc tests compared adjusted 6-month scores for the extensive intervention group (EIG) and minimal intervention group (MIG) with those of the control group (CG): [†] $P < .05$; [‡] $.01$.

not statistically significant, the intervention appeared to have a greater effect on those with a greater risk of falls (PPA falls risk score ≥ 2).

DISCUSSION

This study examined the effectiveness of individualized interventions to prevent falls that targeted physiological risk factors. It was found that the interventions were effective in improving some measures of vision and strength and producing small changes in PPA falls risk scores, but unlike recent physiotherapy-based³⁻⁵ and group exercise interventions⁷⁻⁹ and certain multifactorial interventions,^{15,16} the interventions were not sufficient to prevent falls.

A strength of the study was the validated assessment for identifying subjects with physiological deficits that may be amenable to intervention. The inclusion criteria of poor

performance on one or more PPA test items was probably not sufficiently stringent, because only 9% of the sample was excluded, and the fall rates were only marginally higher than that reported in a similar sample of community-dwelling older people.³⁷ It is likely that inadequate targeting of individuals at high risk for falls was a major reason that the interventions were not successful in preventing falls.³⁸ The intervention may have had a greater effect in those with increased fall risk,^{7,12} although the study was not adequately powered to determine this.

There were improvements in some physical performance measures at 6 months in subjects who received the EIG exercise. When compared with previous studies of group exercise undertaken in community settings,^{8,39,40} the effects of this program were minimal. Most notably, there was no improvement in the standing and leaning balance tests in the EIG, which indicates that the exercises were of

Table 3. Baseline and 6-Month Scores for Tests Relevant to the Vision Intervention

Test Variable	EIG (n = 64)		MIG (n = 62)		CG (n = 69)	
	Baseline	6 Month	Baseline	6 Month	Baseline	6 Month
	Mean ± Standard Deviation					
Visual acuity high (MAR)	1.35 ± 0.51	1.33 ± 0.58 [‡]	1.50 ± 0.81	1.48 ± 1.10 [†]	1.26 ± 0.62	1.56 ± 0.51
Visual acuity low (MAR)	2.73 ± 1.41	2.70 ± 1.62 [†]	2.73 ± 1.15	2.86 ± 1.44*	2.71 ± 1.73	3.22 ± 2.57
Edge contrast sensitivity (dB)	17.8 ± 1.9	18.5 ± 2.3*	17.5 ± 2.0	17.6 ± 2.2	18.3 ± 2.5	18.0 ± 2.8
Depth perception (cm error)	3.6 ± 3.8	3.7 ± 4.3	4.0 ± 4.2	3.9 ± 4.3	2.7 ± 3.6	3.5 ± 4.5

Overall F statistics indicated significant differences between the groups for high-contrast visual acuity ($P < .001$), low-contrast visual acuity ($P < .01$), and edge-contrast sensitivity ($P < .05$). Post hoc tests compared adjusted 6-month scores for the extensive intervention group (EIG) and minimal intervention group (MIG) with those of the control group (CG): * $P < .05$; [†] $.01$; [‡] $.001$.

MAR = minimum angle resolvable in minutes of arc.

Table 4. Falls in the Three Intervention Groups During the 12-Month Trial

Falls	CG	EIG	RR (95% CI)	MIG	RR (95% CI)
Total sample	(n = 201)	(n = 202)		(n = 194)	
Falls, n (rate)*	175 (0.871)	183 (0.906)	1.03 (0.78–1.35) [†]	152 (0.784)	0.90 (0.69–1.17) [†]
≥1 falls, n (%)	90 (44.8)	93 (46.0)	1.03 (0.83–1.27) [‡]	94 (48.5)	1.08 (0.88–1.34) [‡]
≥2 falls, n (%)	45 (22.4)	49 (24.3)	1.08 (0.76–1.54) [‡]	37 (19.1)	0.85 (0.58–1.26) [‡]
Injuries, n (rate)*	108 (0.537)	119 (0.589)	1.07 (0.79–1.44) [†]	97 (0.500)	0.93 (0.68–1.27) [†]
≥1 injuries, n (%)	67 (33.3)	80 (39.6)	1.19 (0.92–1.54) [‡]	72 (37.1)	1.11 (0.85–1.46) [‡]
Falls risk ≥2	(n = 62)	(n = 55)		(n = 53)	
Falls, n (rate)*	72 (1.161)	55 (1.000)	0.82 (0.52–1.31) [†]	57 (1.075)	0.83 (0.53–1.31)
≥1 falls, n (%)	37 (59.7)	25 (45.5)	0.76 (0.53–1.09) [‡]	28 (52.8)	0.89 (0.64–1.23)
≥2 falls, n (%)	17 (27.4)	15 (27.3)	0.99 (0.55–1.80) [‡]	16 (30.2)	1.10 (0.62–1.96)
Injuries, n (rate)*	49 (0.790)	36 (0.655)	0.78 (0.47–1.30) [†]	34 (0.642)	0.75 (0.45–1.27)
≥1 injuries, n (%)	30 (48.4)	20 (36.4)	0.75 (0.49–1.16) [‡]	21 (39.6)	0.82 (0.54–1.25)

* Fall and injury rates calculated as total number of event in group/group number.

[†] Incidence rate ratios calculated for comparing the rate of falls in the extensive intervention group (EIG) and minimal intervention group (MIG) with those in the control group (CG), adjusting for falls in the previous year.

[‡] Relative risks (RRs) calculated for comparing the number of fallers in the EIG and MIG with that of the CG.

CI = confidence interval.

insufficient intensity or of an inappropriate nature to produce gains in these important domains. Administering the individualized exercise program in a group setting was challenging for the exercise trainers, particularly when the group comprised participants of varying functional abilities. A simplified program consisting of an optimal set of core exercises for participants with similar abilities or using a circuit class design may be more appropriate in a group setting.^{8,39–42} Compliance with the exercise program was also only poor to fair.

Only one previous study has specifically assessed interventions to maximize vision as a strategy for preventing falls.⁹ This study found that vision interventions alone were not effective in preventing falls. In the current study, there were significant differences at 6 months between the EIG and the CG in the tests of visual acuity and contrast sensitivity. These differences resulted from small improvements in visual performance in the EIG and from declining visual performance in the CG. The changes in visual acuity in the CG between baseline and retest were greater than what would be expected as a result of age-related declines and may have been due to other factors, such as the use of sub-optimal glasses at the 6-month assessment. Despite the significant differences, the effects of the visual intervention were small and may be of limited clinical significance.

Compliance with most of the visual intervention recommendations was adequate, although fewer subjects agreed with the recommendation not to wear multifocal glasses outside the home. This may have been partly due to the counseling session being too brief and following the baseline PPA assessment directly. The subjects may have been provided with too much information and therefore not have been receptive to the explanation of the rationale. These limitations were also relevant for the counseling intervention for addressing impaired sensation. These components need greater development, with input from focus groups, and require greater explanation and reinforcement.

Although subject allocation to groups was randomized, the groups differed with respect to the main outcome meas-

ure (fall rates) at baseline as well as fear of falling levels. The differences in these measures, as well as trends for measures such as reported arthritis and poor health status, suggest that the EIG had the poorest levels of physical functioning of the three groups and the MIG had the best. This appears to have been reflected in fall rates in the trial period.

An extended version of the PPA was used in this research trial, and an assessment of this complexity is not feasible in many clinical practice settings. The short-form PPA,²² which takes 15 minutes to administer, is a practical alternative and is now being used in numerous falls clinics. PPA tests and fall risk scores have also proved useful as outcome measures in previous exercise intervention trials.^{8,9,27,39,40} The current study was the first to attempt to individualize interventions using the full PPA profile. These interventions produced only small reductions in falls risk and did not prevent falls. The lack of an effect on falls may reflect insufficient targeting of the intervention to an at-risk group, difficulties of delivering an individualized exercise program in a group setting, and counseling interventions that were too brief and not optimally timed. Improvements in designing and implementing interventions are therefore required to make greater use of the information provided by PPA profiles and falls risk scores.

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