The Journal of Nutrition, Health & Aging©
Volume 14, Number 7, 2010

JNHA: GERIATRIC SCIENCE

BALANCE AND WALKING SPEED PREDICT SUBSEQUENT 8-YEAR MORTALITY INDEPENDENTLY OF CURRENT AND INTERMEDIATE EVENTS IN WELL-FUNCTIONING WOMEN AGED 75 YEARS AND OLDER

H. BLAIN[1], I. CARRIERE[2], N. SOURIAL[3], C. BERARD[4], F. FAVIER[5], A. COLVEZ[1], H. BERGMAN[3]

1. Department of Internal Medicine and Geriatrics, University Hospital of Montpellier, University Montpellier 1, 34295, France; 2. Inserm U888, University Montpellier 1, 34093 Montpellier, France; 3. Division of Geriatric Medicine, Jewish General Hospital, McGill University, Montreal, Quebec, Canada; 4. INSERM U780, 16 rue Paul Vaillant-Couturier, 98807 Villejuif, France; 5. INSERM CIC-EC, Groupe Hospitalier Sud Réunion, 97410 Saint Pierre, France. Correspondence: Address correspondence to Hubert Blain, CHU de Montpellier, Département de Médecine Interne et Gériatrie, Centre Antonin Balmes, 34000 Montpellier, France, Tel: +33 467-336-790 Fax: +33 467-336-887, E-mail: h-blain@chu-montpellier.fr

Abstract: *Background:* Physical performance may predict survival independently of other current predictors in non selected elderly subjects. We determined if poor balance and decreased gait speed may predict mortality after adjustment for both baseline and follow-up confounders in well-functioning elderly women. *Methods:* A subgroup of participants in the Epidemiology of osteoporosis (EPIDOS) study (N = 1,300) was followed for 8 years. Participants were community-dwelling women aged 75 or older able to go outside home without assistance. The baseline examination included a questionnaire and a clinical and functional examination. Participants were contacted every year thereafter by mail. *Results:* Poor balance, defined by the inability to stand in a tandem position or to complete ten foot taps in less than 4.6 seconds, and poor mobility, defined by a gait speed of less than 0.80 m/s or a stride length of less than 0.5 m were significant predictors of low 8-year survival, independently of other predictors of death at baseline (educational level, social network, number of drugs, fear of falling, visual acuity, perceived health, IADL score, physical activity, and comorbidities) and during follow-up (falls, IADL score, the need to be accompanied to go outside, weight loss, hospitalization, and the report of new comorbidities). *Conclusion:* The current study shows that poor balance and mobility are significant predictors of 8-year mortality independently of baseline and intermediate events in pre-disabled women aged 75 years and older, suggesting that they may reflect a certain failure to respond adequately in the face of present and future medical and non-medical events.

Key words: Longitudinal studies, cox models, frailty, elderly.

Studies predicting mortality in elderly persons aim to identify risk factors enabling early intervention to help increase active life expectancy and improve quality of life. Risk factors of death in elderly people are numerous, including age, male gender, low economic and social status and support, and noxious lifestyle behaviors such as tobacco use or low exercise, in particular (1–2). Low survival is also observed in elderly subjects with comorbidities or conditions such as cancer, hypertension, diabetes mellitus, stroke, depression, cognitive impairment, limited vision, obesity, malnutrition, or weight loss (1, 2, 3–9). Survival is also decreased in older subjects with dependence on daily living activities (ADLs) or on instrumental daily living activities (IADLs) and during and after hospitalization (3, 10, 11).

A poor functional status defined by poor mobility, decreased muscle strength and poor balance have been found to be associated with a poor prognosis in elderly subjects, even after adjustment for several of the above risk factors, suggesting that they may be the reflection of a certain inability to respond adequately to current stressors or may be the marker of underlying diseases not yet diagnosed (12–15). Because these studies include most often elderly persons with different degrees of disability and because intermediate events between baseline and death are not taken into account in these studies, it remains to be determined whether physical performance markers may reflect, in pre-disabled older women, a certain failure to integrate adequate responses in the face of future medical and non-medical stressors.

To test the hypothesis that poor balance, gait speed, and muscle strength may be associated with mortality independently of both current and future stressors in well-functioning elderly women, we investigated the effects of balance, gait parameters and muscle strength on subsequent 8-year mortality in community-dwelling women aged 75 and older able to go outside home without assistance, when taking into account baseline and follow-up sociodemographic, medical and non-medical events.

Materials and methods

Study sample

In 1992 or 1993, 1548 women were enrolled in Montpellier, one of the five French EPIDOS (EPIDemiology of OSteoporosis) study centers. The EPIDOS study was an epidemiologic prospective study of risk factors for hip fracture (16). Participants were Caucasian community-dwelling women aged 75 years and older recruited through random-sampling using the voting lists and several health insurance company registers. To participate, women had to be able to walk independently without a cane, to be in sufficient physical and

Received March 25, 2009
Accepted for publication September 15, 2009

cognitive health to be able to come without assistance to the local clinical center, perform functional tests, and to reply to a 45-minute questionnaire. Women who had undergone a bilateral hip replacement or had previously suffered a hip fracture were excluded. Were also excluded women with Paget's disease of bone, malignant bone disease, renal failure, hyperthyroidism, or treated hypothyroidism.

The baseline examination was done by trained doctors and nurses and included a questionnaire, a clinical and functional examination and whole body BMD measurements. Participants in the Montpellier center were contacted every year thereafter by mail until the end of 2000 so that information about medical and non-medical life events could be obtained.

The cohort consists of 1331 women included in 1992–1993 in the EPIDOS study in Montpellier and with vital status on January 1, 2001, i.e. after 8 years of follow-up. To better understand the effect of baseline predictors of mortality in otherwise rather well-functioning older women, the 31 women who died during the first one-year follow-up were excluded, leaving 1300 women in the present analysis.

Outcome Variable

Mortality between the end of the first one-year follow-up (1993-1994) and January 1, 2001, was used as the outcome variable. Date of death was provided by the French National Death Registry.

Baseline candidate risk factors of subsequent mortality

Balance was estimated by the time during which the women were able to remain in a side-by-side position, in a tandem position (heel-to-toe), and by the time to complete ten foot taps. Difficulty in performing a tandem walk was also quantified (unable without stepping off, or unable or refusal, or unable without a stick). Walking speed and the number of steps taken over a 6-meter course at usual pace were also measured. Grip strength was measured with a Jamar Dynamometer and knee extension strength was measured in a sitting position using a custom-built dynamometer chair. The time to complete five chair stands with the arms crossed was also recorded.

Other baseline factors

The baseline evaluation included the following parameters, considered as possible confounding factors of the relationship between mortality and balance, gait speed, and muscle strength: sociodemographic variables (age, marital status, level of education, per capita household income divided into "<19,000 dollars per year" vs "≥19,000 dollars per year"); markers of social support (household structure, the membership in an association, the number of times women who went on vacation during the last year); self-perception of health (divided into "healthier", "as healthy as" or "less healthy" than peers); fear of falling; self-report of the most common chronic diseases confirmed or validated by medication use or medical records, including pulmonary disease, cancer, diabetes mellitus, stroke, cardiovascular disease, ostearthritis, neuropsychiatric disease, deep venous thrombosis; functional status assessed by ADL and IADL scores; cognitive function assessed by the Pfeiffer test (17); corrected visual acuity measured with a Snellen letter test chart; number of drugs taken per day; tobacco and alcohol use dichotomized as any use versus none; hospitalization in the last year; physical activity obtained by questionnaire and converted into metabolic equivalents (MetS) per week (18); anthropometric measurements, including body weight, body height, waist circumference, hip circumference, and calf circumference. Whole body BMD, hip BMD and whole body lean mass and fat mass were measured with a Lunar DPX-Plus. All the parameters recorded at baseline and during follow-up have been described in detail elsewhere (16).

Follow-Up Medical and Non–Medical Events

Health events ascertained during the follow-up included overnight hospitalization, functional status assessed by the IADL score and by the need to be accompanied to go out, and any new diagnosis of infection, dysthyroidism, diabetes mellitus, cancer, cardiovascular disease, congestive heart failure, stroke, peripheral arterial disease, deep venous thrombosis, osteoarthritis, visual dysfunction, fractures, or gastrointestinal disorder. Subjects were asked whether they had fallen (binary variable) and if so, whether at least three falls occurred since the last questionnaire (binary variable). Women were also questioned about their dietary intake ("having eaten less", "as much as" or "more" than the year before) and weight ("less", "the same as" or "more" than the year before), and about their self-perceived health.

Statistical Analysis

The first analysis explored the 8-year risk of death associated with baseline measurements of balance, gait parameters, and muscular strength. These factors were tested in a univariate model and in a multi-adjusted model. Adjustment was made for baseline factors associated with mortality at the 25% level.

The second analysis assessed the associations between mortality and factors evaluated yearly throughout the seven years of follow-up as time-dependent covariates. All the time dependent factors were tested in a univariate model. In this analysis, the effect of a risk factor assessed at year t on the probability to die between t and t+1 was modeled. When a time point was missing, the data of the preceding point were carried forward. The covariates found to be linked to mortality with a p-value lower than 0.25 were then kept for the next step.

The final analysis recalculated the risk associated with baseline measurements of balance, gait parameters, and muscle strength and adjusted for time-dependent covariables.

The Cox model was used taking age as the basic time scale and birth as the time origin. This method avoids the problem of non-proportionality of the risk of death with age. As the women included in the study had different ages, the Cox model with delayed entry was used. To analyze possible non-linear associations, continuous covariates were categorized by quartiles and the hazard ratio (HR) of mortality was expressed for the categories of each variable, relative to the reference category for this variable for which the mortality risk was the lowest.

We used multiple imputations by generating 5 copies of the original data set, in which missing values for covariates considered in the analysis were replaced by values generated according to the Markov Chain Monte Carlo (MCMC) method (19). For this procedure, we used the PROC MI procedure of SAS version 9.1. Of the 1300 women included in the analysis, 248 (19.08%) had missing data for at least one of the following baseline variables: time to stand in a side-by-side position, time to stand in a tandem position, mean time to complete ten foot taps, difficulty in performing a tandem walk, walking speed, number of steps to walk 6 meters, time to complete five chair stands, grip strength, knee extension strength, waist circumference, falls, visual acuity, perceived health, social network, IADL, physical activity and smoking or for at least one of the following follow-up variables: IADL, the need to be accompanied, weight change, perceived health, hospitalization. The rate of missingness varied from 0.15% for walking speed to 8.6% for knee extension strength. Each imputed data set was analyzed as if it were complete in order to calculate the mean HR and their confidence interval by the PROC MIANALYZE procedure.

Results

Table 1 displays the characteristics of the 1300 women entered into the analysis. Among these women, 410 died by the end of the study (January 1, 2001).

The relationships between baseline measures of balance, gait parameters, and muscle strength and the 8-year mortality are displayed in Table 2, before and after adjustment for baseline parameters associated with subsequent mortality. Poor balance, measured by the time to stand in a tandem position or to complete ten foot taps, and slow walking speed and short stride length remained baseline predictors of low survival after full adjustment.

Follow-up predictors of low survival were recurrent falls (more than 3 falls during the follow-up), the dependence for at least one IADL, the need to be accompanied to go outside the house, the self-report of weight loss, a poor self-perceived health (less healthy than peers), hospitalization during the last year of the study, and the reporting of new conditions including pulmonary diseases, cancer, diabetes mellitus, cardiovascular disease, stroke, and deep venous thrombosis.

The relationships between mortality and baseline measures of balance, gait parameters and muscle strength after adjustment for baseline and follow-up factors are also displayed in Table 2. Poor balance, measured by the time to stand in tandem position or to complete ten foot taps and a decreased gait speed or decreased stride length were found to be predictors of 8-year mortality, independently of baseline and follow-up factors. The results were very similar when women with missing data were excluded from the analysis (data not shown).

Table 1
Associations between baseline characteristics and 8-year mortality (N = 1,300)

Characteristics	Alive N=890 %	Dead N=410 %	HR (95% CI)‡	p-value‡
Age in years [median (IQR)]	79 (77-81)	81 (79-84)		
Educational level: primary school	55.5	66.3	1.29 (1.05, 1.59)	0.01
Number of drugs				
<3	18.7	12.5	1	
3-4	25.8	20.7	1.11 (0.78, 1.57)	< 0.0001
5-6	27.4	26.3	1.32 (0.94, 1.84)	
7+	28.1	40.5	1.84 (1.34, 2.51)	
Cognition (Pfeiffer's test ≥ 3)	8.2	21.5	1.59 (1.24, 2.03)	0.0002
Smoker (current or former)	13.8	13.9	1.15 (0.86, 1.52)	0.34
Fear of falling	48.8	55.6	1.14 (0.94,1.39)	0.19
Visual acuity < 40	13.6	24.9	1.24 (0.98, 1.59)	0.08
Perceived health				
As healthy or less healthy	64.2	68.5	1.32 (1.06, 1.64)	0.01
Social network				
Membership to an association	49.1	42.9	0.88 (0.72, 1.07)	0.19
Yearly holidays	60.6	50.2	0.81 (0.67, 0.98)	0.03
IADL*				
No limitations	70.4	47.9	1	<0.0001
1-2 activity limitations	22.7	30.2	1.34(1.06, 1.69)	
3-4 activity limitations	4.5	12.4	2.05 (1.50, 2.82)	
5+ activity limitations	2.4	9.5	1.94 (1.35, 2.77)	
ADL† (%)				
At least one limitation	4.9	13.9	1.68 (1.27, 2.24)	0.0004
Physical activity < 0.88 Meq	20.1	33.9	1.48 (1.20, 1.81)	0.0002
Body mass index in kg/m2				
< 18	1.4	1.7	1.33 (0.62, 2.83)	
18-25	42.1	43.2	1	0.17
25-30	42.1	37.8	0.88 (0.71, 1.09)	
≥30	14.4	17.3	1.18 (0.89, 1.55)	
History of diabetes	2.4	5.1	2.24 (1.44, 3.48)	0.0003
History of neuropsychiatric disease	3.8	4.2	1.31 (0.81, 2.13)	0.27
History of cardiovascular disease	14.0	17.6	1.31 (1.02, 1.69)	0.04
History of deep venous thrombosis	5.6	8.5	1.48 (1.05, 2.10)	0.03
History of pulmonary disease	2.9	6.6	2.03 (1.37, 3.00)	0.0004

IQR: Inter-quartile range; *IADL: Instrumental Activities of Daily Living (doing light housework, doing laundry, shopping for groceries, preparing meals, using the telephone, taking transportation, managing money, taking medications)†ADL: Activities of Daily Living (bathing, dressing, getting in and out of a bed); ‡ Cox model adjusted for age

Discussion

The main results of the present study are that slow walking speed and poor balance at baseline are both significant predictors of 8-year mortality, independently of both baseline and follow-up risk factors of death, in well-functioning women aged 75 years and older living in the community. The fact that the relationships persist after adjusting for post-baseline events (new IADL, weight changes, hospitalization, incident diseases)

Table 2
Hazard ratio of 8-year mortality according to baseline and follow-up factors (N = 1,300)

	Unadjusted			Baseline covariate adjusted*			Follow-up covariate adjusted†		
	Hazard ratio	95% CI	P- Value	Hazard ratio	95% CI	P- Value	Hazard ratio	95% CI	P- Value
Balance and coordination									
Time to stand in side-by-side position (sec)			.003			.22			.21
< 5 vs = 10	1.49	(1.19; 1.88)		1.24	(0.97; 1.57)		1.23	(0.98; 1.56)	
[5;10[vs = 10	1.14	(0.88; 1.47)		1.06	(0.81; 1.37)		1.07	(0.83; 1.39)	
Time to stand in tandem position (sec)			<.0001			.01			.02
0 vs [6; 10]	1.81	(1.27; 2.58)		1.42	(0.98; 2.05)		1.33	(0.93; 1.92)	
]0; 6[vs [6; 10]	1.10	(0.78; 1.55)		1.00	(0.70; 1.42)		0.99	(0.70; 1.42)	
Mean time to complete ten foot taps (sec)			<.0001			.01			.05
[4.60; 5.70[vs <4.60	1.67	(1.21; 2.31)		1.54	(1.10; 2.14)		1.53	(1.10; 2.13)	
[5.70; 7.40[vs <4.60	1.50	(1.08; 2.09)		1.32	(0.94; 1.86)		1.31	(0.93; 1.84)	
≥ 7.40 vs <4.60	2.15	(1.57; 2.94)		1.69	(1.20; 2.37)		1.51	(1.08; 2.10)	
Difficulty in performing a tandem walk			.004			.77			.79
Unable without stepping off	1.28	(1.01; 1.62)		1.10	(0.86; 1.41)		1.10	(0.86; 1.40)	
Unable or refusal	1.54	(1.18; 2.01)		1.13	(0.84; 1.51)		1.14	(0.87; 1.50)	
Unable because need a stick	1.95	(1.16; 3.27)		1.27	(0.73; 2.21)		1.17	(0.68; 2.02)	
Mobility									
Walking speed in m.s-1			<.0001				.002		.03
<0.66 vs ≥ 0.93	2.45	(1.78; 3.36)		1.86	(1.29; 2.68)		1.56	(1.11; 2.21)	
[0.66; 0.80[vs ≥ 0.93	1.99	(1.44; 2.76)		1.74	(1.23; 2.45)		1.55	(1.10; 2.17)	
[0.80; 0.93[vs ≥ 0.93	1.33	(0.94; 1.88)		1.26	(0.88; 1.80)		1.20	(0.84; 1.71)	
Number of steps to walk 6m			<.0001			.007			.10
[12; 13] vs <12	1.02	(0.72; 1.45)		0.99	(0.69; 1.41)		0.96	(0.67; 1.36)	
[13; 14.5] vs <12	1.44	(1.04; 2.02)		1.27	(0.90; 1.79)		1.13	(0.80; 1.59)	
≥ 14.5 vs <12	2.12	(1.55; 2.89)		1.63	(1.15; 2.31)		1.36	(0.97; 1.89)	
Muscular strength									
Grip strength (in Kpa)			.14			.45			.83
<43 vs ≥ 58	1.36	(1.02; 1.82)		1.22	(0.90; 1.65)		1.09	(0.81; 1.47)	
[43; 50[vs ≥ 58	1.19	(0.89; 1.60)		1.05	(0.77; 1.43)		1.04	(0.77; 1.40)	
[50;58[vs ≥ 58	1.07	(0.79; 1.44)		1.00	(0.73; 1.36)		0.96	(0.71; 1.30)	
Knee extension strength (Newton/lower leg length in cm)				.03		.26			.15
< 3.18 vs ≥ 4.70	1.52	(1.12; 2.07)		1.20	(0.88; 1.64)		1.22	(0.89; 1.67)	
[3.18; 3.93[vs ≥ 4.70	1.52	(1.11; 2.07)		1.36	(0.99; 1.86)		1.43	(1.04; 1.95)	
[3.93; 4.70[vs ≥ 4.70	1.39	(0.99; 1.96)		1.30	(0.92; 1.83)		1.32	(0.94; 1.86)	
Time to complete five chair stands (sec)			.0005			.19			.37
[10.5; 12.5[vs <10.5	1.07	(0.78; 1.48)		0.98	(0.71; 1.36)		0.90	(0.65; 1.26)	
[12.5; 15.2 [vs <10.5	1.49	(1.10; 2.00)		1.28	(0.94; 1.75)		1.17	(0.86; 1.59)	
≥ 15.2 vs <10.5	1.68	(1.25; 2.24)		1.25	(0.91; 1.71)		1.08	(0.79; 1.46)	

CI: Confidence interval; *Adjusted for educational level, number of drugs, cognition (Pfeiffer's test), fear of falling, visual acuity, perceived health, social network, IADL, physical activity, diabetes mellitus, psychiatric diagnosis, cardiovascular disease, deep venous thrombosis, pulmonary disease and osteoarthritis. †Adjusted for educational level and the last year follow-up factors: number of falls, IADL, need to be accompanied, weight change, perceived health, hospitalization, pulmonary disease, cancer, diabetes mellitus, stroke, cardiovascular disease, osteoarthritis, neuropsychiatric diagnosis, and deep venous thrombosis.

further strengthens the predictive value of slow walking speed and poor balance. These results suggest that a walking speed of less than about 0.80 meters per second and difficulties to hold a tandem position or to complete ten foot taps in less than 4.6 seconds may be relevant to identifying non-disabled women aged 75 years and older, however at higher risk for health decline and lower survival.

Predictors of mortality in older women are numerous, including in the present as in previous studies, a low educational level, a poor social network, a low physical activity, the self-report of the fear of falling (20−22), a dependence in IADLs (11), a poor perceived health (10, 23), a high number of drugs taken (24), and the self-report of comorbidities such as cardiovascular, or pulmonary diseases, depression, poor visual acuity, diabetes mellitus, or deep venous thrombosis (1, 3, 5, 7, 9, 10, 12).

For the first time to our knowledge, slow gait speed was found to be a predictor of 8-year mortality, independently of all the above baseline and follow-up predictors of survival. Taken together, the present results suggest that low gait speed may help to identify women at risk of adverse health outcome due to impaired capability to withstand current but also future medical and non-medical events. This hypothesis is in accordance with previous studies showing that slow gait speed may predict

The Journal of Nutrition, Health & Aging©
Volume 14, Number 7, 2010

lower survival in patients suffering from severe heart disease (25) and that improvement or decline in usual gait speed may predict placement decision after rehabilitation (26), and mortality in older subjects (27, 27). The present results also support the hypothesis that a short stride length at usual pace (< 0.5 meter) may have the same value as a slow gait speed to predict low survival in elderly women (29).

In the present study, poor balance predicted also low survival, independently of follow-up factors, including falls, disability, and self-report of cardiovascular and cerebrovascular diseases. Taken together, these results may suggest that poor balance, like slow gait speed or short stride length, might indicate a certain inability to improve or recover from future stressful events (13). These results provide further justification to integrate the measurement of balance and gait speed (6, 12, 15, 30) or stride length at usual pace in prognostic assessment tools in non-disabled elderly women and to consider balance and mobility as subclinical indicators of "physical reserve" or "vital signs" (31, 32). Slow gait speed and balance disturbances could be, in part, the reflection of poor global and executive cognitive functions, involved in individual adaptation to current and future stressors (33).

Weak grip strength, often measured in prognosis assessment tools, is widely considered as a marker of decreased reserves and poor prognosis in older subjects (6, 7, 34). In the present study and in a recent study, low muscle strength was not an independent predictor of subsequent mortality, suggesting that measuring muscle strength could be less useful than measuring mobility and balance to assess prognosis in non-disabled women (35). Based on literature reports, it may be speculated that low muscle strength may be a better marker of short-term mortality in disabled women (30) and a predictor of future mobility limitation or disability in well-functioning women (36, 37).

Gait speed and balance can be a target for intervention through medical, rehabilitative, and health-promoting behavioral strategies in healthy and in frail older women (38–40). It remains however to demonstrate whether interventions to improve gait speed and balance may improve long-term physical function and survival in well-functioning women with however slow gait speed or poor balance performance.

The present study has several strengths, including an assessment of the association between functional status and mortality after adjustment for current and follow-up factors in elderly women. This point is important since the disabling process is considered as a dynamic condition in older subjects, with possible recovery (1, 6, 34, 35, 41). The baseline medical questionnaire was completed by two trained doctors and all data were confirmed or validated by medication use or medical records. We can therefore be confident with the validity of the medical data recorded at baseline. The results presented herein were obtained in women aged 75 years and older, living at home, without ADL dependency for 92.2% of them and without IADL dependency for 73.3% of them, and followed for a quite long period (8 years). These results obtained in non-disabled women are of special interest since well-functioning older subjects are probably in the best position to benefit from preventive interventions and health care maintenance efforts (42).

Although our results are limited by the low number of obese women, excess body weight at baseline was not associated with mortality after 8 years follow-up. Interestingly, Lang et al. demonstrated recently in non-institutionalized men and women aged 65 years or older followed for 5 years that excess body weight had stronger associations with impaired physical function than with mortality (43). The lower effect on mortality of excess body weight in older people than in younger adults might be due at least in part to a survival bias, older obese people being also possibly those who are resilient to some noxious effects of excess body weight (43, 44).

Several limitations need to be taken into account when interpreting the present results. Firstly, the women studied in our study were aged 75 and older at baseline and from a European Caucasian population; this may limit the generalization of our findings to women with more or less advanced ages, to men, and to other ethnic groups (7, 23). Secondly, we failed to include baseline and follow-up quantitative measures of diseases that have been shown to be better predictors of mortality than clinical history of diseases (3). The present study did not include subjects with cognitive impairment at baseline, even if cognitive impairment was not an exclusion criterium. The results are therefore valid only in non-demented older women. The fact that present study included only high-functionning women aged 75 years or older, able to walk independently without a cane and in excellent physical and cognitive health, explains at least in part the low prevalences at baseline of morbidities, such as cardiovascular diseases, diabetes, and obesity and the low mortality after 8 years of follow-up (less than 25%). The present results are therefore not extrapolable to older women with higher prevalences of comorbidities. Another limitation is due to the number of comparisons made (9 measures of balance, strength and mobility). We therefore cannot exclude that some of the observed associations were due to a chance finding.

Three key messages can be drown from our findings. First, our results support the idea that measuring both balance and mobility is of great interest in well-functioning women aged 75 years and older living at home since poor balance and mobility performances are associated with significant increased risk of mortality for the susequent 8 years. Second, both balance and mobility are associated with significant increased risk of mortality, independently of baseline and follow-up factors, suggesting that the maintenance of balance and mobility with aging may reflect physical reserves to respond adequately in the face of present and future stressors. Third, since balance can easily be assessed by the time to stand in tandem position without stepping off or by the time to complete ten foot taps, and since mobility can easily be assessed by the walking speed over a 6-meter course, screening poor mobility and balance performances in high-functioning women seems to be feasible at the population level.

Further studies are now needed to determine the precise mechanisms explaining why balance and mobility may reflect an ability to respond adequately in the face of present and future stressors and whether a multidimensional intervention aimed at increasing balance and gait speed in this subgroup of non-disabled women, but however on a trajectory of health decline, may help increase their active life expectancy.

Acknoledgements: The EPIDOS Study participants included coordinators (G. Breart, P. Dargent-Molina, P.J. Meunier, A.M. Scott, D. Hans , and P.D. Delmas) and principal investigators, (C. Baudoin and J.L. Sebert (Amiens), M.C. Chapuy and A.M. Scott (Lyon), F. Favier and C. Marcelli (Montpellier), C.J. Menkes, C. Cormier, and E. Hausherr (Paris), and H. Grandjean and C. Ribot (Toulouse)]. The authors are very grateful to S.L. Salhi, PhD, for presubmission editorial assistance.

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