

# Rethinking the Association of High Blood Pressure With Mortality in Elderly Adults

## The Impact of Frailty

Michelle C. Odden, PhD; Carmen A. Peralta, MD, MAS; Mary N. Haan, DrPH; Kenneth E. Covinsky, MD, MPH

**Background:** The association of hypertension and mortality is attenuated in elderly adults. Walking speed, as a measure of frailty, may identify which elderly adults are most at risk for the adverse effects of hypertension. We hypothesized that elevated blood pressure (BP) would be associated with a greater risk of mortality in faster-, but not slower-, walking older adults.

**Methods:** Participants included 2340 persons 65 years and older in the National Health and Nutrition Examination Survey, 1999-2000 and 2001-2002. Mortality data were linked to death certificates in the National Death Index. Walking speed was measured over a 20-ft (6 m) walk and classified as faster ( $\geq 0.8$  m/s [n=1307]), slower (n=790), or incomplete (n=243). Potential confounders included age, sex, race, survey year, lifestyle and physiologic variables, health conditions, and antihypertensive medication use.

**Results:** Among the participants, there were 589 deaths through December 31, 2006. The association between BP and mortality varied by walking speed. Among faster walkers, those with elevated systolic BP ( $\geq 140$  mm Hg) had a greater adjusted risk of mortality compared with those without (hazard ratio [HR], 1.35; 95% CI, 1.03-1.77). Among slower walkers, neither elevated systolic nor diastolic BP ( $\geq 90$  mm Hg) was associated with mortality. In participants who did not complete the walk test, elevated BP was strongly and independently associated with a lower risk of death: HR, 0.38; 95% CI, 0.23-0.62 (systolic); and HR, 0.10; 95% CI, 0.01-0.81 (diastolic).

**Conclusions:** Walking speed could be a simple measure to identify elderly adults who are most at risk for adverse outcomes related to high BP.

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**H**YPERTENSION IS A MAJOR public health problem in the United States that has prompted extensive efforts to increase awareness and treatment.<sup>1</sup> The prevalence of hypertension is increasing, and rates of control remain suboptimal.<sup>2</sup> The high prevalence of hypertension has been, at least in part, attributed to the increase in blood pressure

The data on optimal BP goals are especially limited in the oldest old.<sup>4</sup> A recent expert consensus document noted that it is “unclear whether target systolic BP should be the same in patients 65 to 79 years of age as in patients  $\geq 80$  years of age.”<sup>4(p2438)</sup> There is substantial evidence from epidemiologic studies demonstrating an attenuated or inverted association between higher BP and mortality at older ages.<sup>6,7</sup> Nonetheless, the Hypertension in the Very Elderly Trial (HYVET) demonstrated a beneficial effect of antihypertensive therapy in adults 80 years and older on stroke, cardiovascular events, heart failure, and death, based on a goal BP of lower than 150/80 mm Hg.<sup>8</sup> Notably, the participants in this trial were healthier than average and had lower prevalence of comorbid conditions. In clinical practice, decisions regarding BP targets are particularly difficult in poor-functioning older adults, who frequently do not meet the inclusion criteria of randomized controlled trials. Thus, whether current targets are ap-

### See Invited Commentary at end of article

**Author Affiliations:** College of Public Health and Human Sciences, Oregon State University, Corvallis (Dr Odden); Departments of Medicine (Drs Peralta and Covinsky) and Epidemiology and Biostatistics (Dr Haan), University of California, San Francisco; and Medical Service, San Francisco VA Medical Center, San Francisco (Drs Peralta and Covinsky).

(BP) with age and the rapid growth of the elderly population (age  $\geq 65$  years).<sup>3</sup> Despite the impact of age on BP, the evidence on BP control in elderly adults is limited and treatment recommendations are the same in older and younger adults.<sup>4</sup> Joint National Committee (JNC) guidelines suggest that “therapy should not be withheld on the basis of age” and recommended BP goals do not differ by age.<sup>5(p1229)</sup>

**Table 1. Characteristics of NHANES Participants 65 Years and Older (1999-2002), Stratified by Walking Speed**

Characteristic	Walking Speed			P Value
	Faster $\geq 0.8$ m/s (n = 1307)	Slower $< 0.8$ m/s (n = 790)	Did Not Complete (n = 243)	
Age, mean (SD), y	72 (6)	77 (6)	77 (6)	<.001
Female, %	52	67	61	<.001
Black race, %	5	10	14	.001
<High school education, %	24	48	45	<.001
Current/prior smoking, %	56	50	47	.02
BMI, mean (SD)	27 (5)	28 (6)	29 (6)	.01
Total cholesterol, mean (SD), mg/dL	212 (39)	212 (45)	206 (40)	.25
HDL-C, mean (SD), mg/dL	54 (16)	54 (18)	53 (17)	.56
Estimated GFR, mean (SD), mL/min/1.73 m <sup>2</sup>	77 (19)	64 (20)	64 (24)	<.001
History of diabetes, %	10	23	23	<.001
History of CHD, %	11	13	12	.72
History of stroke, %	5	12	23	<.001
History of CHF, %	4	13	15	<.001
Antihypertensive medication Use, %	39	54	46	<.001
Systolic BP, mean (SD), mm Hg	139 (21)	143 (23)	147 (30)	.003
Diastolic BP, mean (SD), mm Hg	70 (13)	66 (15)	68 (14)	.001

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); BP, blood pressure; CHD, coronary heart disease; CHF, congestive heart failure; GFR, glomerular filtration rate; HDL-C, high-density lipoprotein cholesterol; NHANES, National Health and Nutrition Examination Survey.

SI conversion factor: To convert cholesterol to millimoles per liter, multiply by 0.0259.

appropriate for this population remains unclear, and how to identify elderly persons who may benefit from lower BP goals is unknown.

We propose that age may be an inadequate measure of the factors that determine the importance of elevated BP. Other measures that better capture frailty and health status may better identify which elderly persons are most at risk for the adverse consequences of hypertension and which may benefit from higher levels of BP. Walking speed is an excellent integrative measure of health; it incorporates function across multiple organ systems, and it is strongly associated with mortality and other adverse events.<sup>9-11</sup> In a previous study of older Latino adults, we demonstrated that systolic BP was associated with mortality only in participants with fast self-reported walking speed.<sup>12</sup> The present study extends this research and examines whether the relationship between elevated BP and mortality varies by objectively measured walking speed among a nationally representative sample of elderly adults. This is a timely and important question, as the clinician strives to reconcile the evidence on the impact of hypertension in the growing elderly population.

## METHODS

### STUDY POPULATION

The National Health and Nutrition Examination Survey (NHANES) is a nationally representative survey of the civilian, noninstitutionalized US population, conducted by the National Center for Health Statistics (NCHS) of the Center for Disease Control and Prevention.<sup>13</sup> Standardized questionnaires were administered in the home, followed by a detailed physical examination at the mobile examination center. This study includes data from participants 65 years and older in 2 waves of the survey (1999-2000 and 2001-2002); 2438 of 2855 (85.4%) completed both the interview and examination (**Table 1**).

### MEASURES

The NCHS has linked mortality data from NHANES to death certificate data in the National Death Index (NDI).<sup>13</sup> Mortality data were available from the date of the survey participation through December 31, 2006, based on a probabilistic match between NHANES and NDI death certificate records.

At the mobile examination center, 3 or 4 BP measurements were taken in sequence on seated participants using a mercury sphygmomanometer. If only 1 BP reading was obtained, that reading was recorded. If there was more than 1 BP reading, the first reading was excluded and the BP was recorded as the average of all subsequent readings. Persons were considered to have elevated BP at levels of 140 mm Hg or higher (systolic) and 90 mm Hg or higher (diastolic), based on current guidelines.<sup>4,5</sup>

Prior research has demonstrated that slow gait speed has the strongest prognostic ability of the traditional components used to assess frailty.<sup>14-16</sup> A 20-ft (6-m)-long test area was set up in a corridor of the mobile examination center. Adhesive tape strips on the floor indicated the start and stop points, and the walk was timed using a handheld stopwatch. The participant was asked to walk at their usual pace. Start and stop times were defined as when the participant's first foot touched the floor across the start line and finish line. We classified slower walkers as walking less than 0.8 m/s, based on the prior literature recommending this cut point,<sup>10</sup> and because it best discriminated between survival times of the fast and slow walkers. A total of 243 participants did not complete the timed walk. The comments on the incomplete walking tests are as follows: safety exclusion (n = 21), participant refusal (n = 22), no time or came late/left early (n = 69), physical limitation (n = 77), ill or emergency (n = 13), other reasons (n = 36), and 5 were missing an explanation.

Age, sex, race, education, smoking, and alcohol use were determined through questionnaire. Height and weight were measured by standard protocol at the mobile examination center, and fasting total and high-density lipoprotein (HDL) cholesterol, triglyceride, and cystatin C levels were measured in se-

**Table 2. Walking Speed by Age and Sex in NHANES Participants 65 Years and Older (1999-2002)<sup>a</sup>**

Sex/Age, y	Walking Speed		
	Faster ≥0.8 m/s (n = 1307)	Slower <0.8 m/s (n = 790)	Did Not Complete (n = 243)
<b>Men</b>			
65-69	243 (77)	52 (16)	21 (7)
70-74	204 (66)	77 (25)	28 (9)
75-79	131 (60)	67 (30)	22 (10)
80-84	103 (50)	91 (44)	12 (6)
≥85	30 (35)	62 (53)	26 (22)
<b>Women</b>			
65-69	206 (65)	80 (25)	31 (10)
70-74	175 (61)	88 (31)	24 (8)
75-79	109 (54)	71 (35)	23 (11)
80-84	72 (33)	122 (56)	24 (11)
≥85	34 (23)	80 (55)	32 (22)

Abbreviation: NHANES, National Health and Nutrition Examination Survey.  
<sup>a</sup>Data are given as number (percentage) of participants.

rum samples also taken during the examination. Estimated glomerular filtration rate was calculated based on the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) group formula ( $76.7 \times \text{cystatin C}^{-1.19}$ ).<sup>17</sup> Self-rated health and whether the participant had anyone to ask for emotional support were assessed by questionnaire. Average daily physical activity, history of diabetes, coronary heart disease, stroke, heart failure, and antihypertensive medication use were also assessed by questionnaire.

### STATISTICAL ANALYSIS

NHANES uses a complex, multistage, probability sampling design; we appropriately accounted for this in all analyses by specifying the sampling design parameters. All analyses were conducted using Stata svy commands (StataCorp).

We first compared the baseline characteristics of the participants with faster and slower walking speed and in those who did not complete the walking test. We calculated the weighted mean and proportions across the continuous and categorical characteristics, respectively, and tested for differences based on the Wald test. We next summarized the mortality rates by level of BP and walking speed and calculated the rate difference in persons with and without elevated BP ( $\geq 140$  mm Hg [systolic] and  $\geq 90$  mm Hg [diastolic]).

We examined the adjusted association of elevated systolic and diastolic BP with mortality in Cox proportional hazards models. We used the Schoenfeld residuals and Kaplan-Meier survival curves to test if the proportional hazards assumption was met. Age, sex, black race, and survey year were included as potential confounders in all models. Other candidate confounders included education (less than high school, high school, more than high school); smoking status (never, former/current); self-rated health (excellent/very good/good, fair/poor); emotional support; physical activity (low, medium, high); body mass index (BMI); total and HDL cholesterol, triglyceride, and cystatin C levels; and history of diabetes, coronary heart disease, stroke, and heart failure. A covariate was included in the adjusted model if it was associated with mortality and BP at a significance level of  $P < .20$ . Of measures examined, education, smoking status, cholesterol level, heart failure, coronary heart disease, and stroke met these criteria. We included multiplicative interaction terms between elevated systolic and diastolic BP and walking speed and used a Wald test for inter-

action. Subsequently, models were stratified on walking speed. We repeated these analyses with systolic and diastolic BP classified as a linear variable.

We conducted several sensitivity analyses. First, we restricted deaths to those with underlying cause of death due to cardiovascular disease (*International Statistical Classification of Diseases, 10th Revision*, code 10 I00-78). Because falling BP levels can be an indicator of the end of life, we conducted an analysis excluding deaths in the first year of follow-up. As an additional sensitivity analysis, we also explored the inclusion of antihypertensive medication use in the multivariable models and also stratified based on medication status. We also stratified by age above and below 75 years. Finally, because not completing the 20-ft (6-m)-walk test may be an indicator of frailty, we grouped the slower walkers and those participants who did not complete the walk test (because of reasons other than logistical) together as a combined, lower-functioning group.

## RESULTS

A total of 2340 participants in NHANES waves 1999-2000 and 2001-2002 were 65 and older and had measured systolic BP; 2282 had measured diastolic BP. The NHANES participants represent a total of 32 million non-institutionalized US adults. Of these participants, 56% had a walking speed of 0.8 m/s or faster, 34% had a walking speed slower than 0.8 m/s, and 10% did not complete the walk for various reasons (described in the "Methods" section). Faster walkers were younger, less often female and black, and more likely to have a high school education compared with slower walkers (Table 1). They were more likely to smoke, had a lower BMI, and had better kidney function. In addition, persons with faster walking speed had less comorbidities compared with those with slower walking speed; they had a lower prevalence of diabetes, stroke, and heart failure. Persons with faster walking speed were less likely to be using antihypertensive medications and had lower systolic BP and higher diastolic BP compared with slower walking participants. Persons who did not complete the timed walk had the highest systolic BP levels. Overall, elevated systolic BP ( $> 140$  mm Hg) was prevalent in approximately 50% of all participants (1164 of 2340), whereas elevated diastolic BP ( $> 90$  mm Hg) was only prevalent in 6% (133 of 2282) of participants. The proportion of men and women who did not complete the walk test was highest in those 85 years and older (Table 2). In all age groups, women were slightly less likely to have a usual walking speed of 0.8 m/s or faster compared with men (Table 2).

By December 31, 2006, there were 589 deaths (representing 7 million US adults); the mortality rate in the study population was 41.7 per 1000 person-years. Faster-walking participants with elevated systolic BP ( $\geq 140$  mm Hg) had a higher mortality rate compared with those with a systolic BP lower than 140 mm Hg, whereas slower walkers with elevated systolic BP did not appear to have increased mortality (Table 3 and Figure 1A). In contrast, among those participants who did not complete the walk test, participants with elevated systolic BP had a lower mortality rate (Table 3 and Figure 1A).

The adjusted association between elevated systolic BP and mortality varied across walking speed ( $P$  value for interaction,  $< .001$ ). Higher systolic BP was associated

**Table 3. The Association of Elevated BP and Mortality, Across Strata of Walking Speed, in NHANES Participants 65 Years and Older (1999-2002)**

BP	Walking Speed		
	Faster $\geq 0.8$ m/s (n = 1307)	Slower $< 0.8$ m/s (n = 790)	Did Not Complete (n = 243)
<b>Systolic BP</b>			
Mortality rate per 1000 person-years			
$\geq 140$ mm Hg	28.1	72.1	62.4
$< 140$ mm Hg <sup>a</sup>	20.4	67.6	133.5
Rate difference	7.7	4.5	-71.1
Unadjusted HR (95% CI) <sup>b,c</sup>	1.39 (0.98-1.96)	1.06 (0.84-1.34)	0.47 (0.29-0.73)
Adjusted HR (95% CI) <sup>b,c</sup>	1.35 (1.03-1.77)	1.12 (0.87-1.45)	0.38 (0.23-0.62)
<b>Diastolic BP</b>			
Mortality rate, per 1000 person-years			
$\geq 90$ mm Hg	24.0	42.5	8.4
$< 90$ mm Hg <sup>a</sup>	23.5	71.3	95.6
Rate difference	0.5	-28.8	-87.2
Unadjusted HR (95% CI) <sup>b,c</sup>	1.01 (0.49-2.07)	0.60 (0.26-1.40)	0.09 (0.01-0.62)
Adjusted HR (95% CI) <sup>b,c</sup>	0.94 (0.38-2.28)	0.75 (0.32-1.75)	0.10 (0.01-0.81)

Abbreviations: BP, blood pressure; HR, hazard ratio; NHANES, National Health and Nutrition Examination Survey.

<sup>a</sup>Reference group.

<sup>b</sup>Adjusted for survey year, age, sex, black race, education, smoking status, cholesterol level, coronary heart disease, heart failure, and stroke.

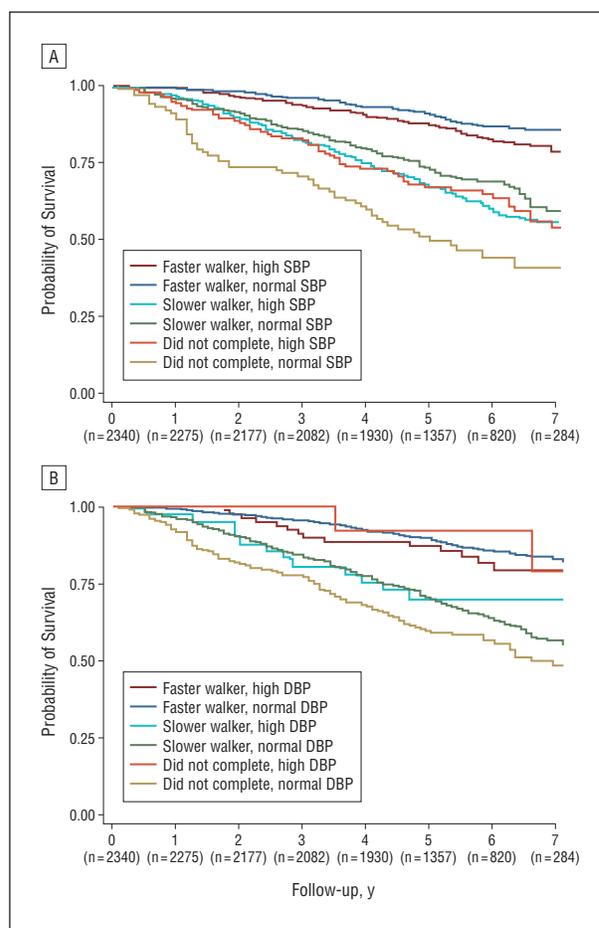
<sup>c</sup>P values for the Wald test for interaction of walking speed categories and elevated systolic BP were  $P < .001$  (unadjusted) and  $P < .001$  (adjusted) and walking speed categories and elevated diastolic BP were  $P = .07$  (unadjusted) and  $P = .21$  (adjusted).

with a 35% elevated risk of mortality in the fast walkers, even after adjustment for potential confounders ( $P = .03$ ) (Table 3 and eTable 1 [http://www.archinternmed.com]). In contrast, there was no association between elevated systolic BP and mortality in the slower walkers ( $P = .37$ ). There was an inverted relationship between elevated systolic BP and mortality in those participants who did not complete the walk test; higher systolic BP was associated with a lower risk of death, even after accounting for potential confounders ( $P < .001$ ).

Faster walkers with elevated diastolic BP did not have a higher mortality rate compared with those without elevated diastolic BP (Table 3 and Figure 1B). Slower walkers with elevated diastolic BP had a lower mortality rate, although the hazard ratio was not statistically significant (Table 3 and eTable 2). In participants who did not complete the walk test, those with elevated diastolic BP had a lower mortality rate compared with those with lower diastolic BP levels, and the adjusted association was strongly in the protective direction ( $P = .03$ ).

Similar patterns of association were present when we classified BP as a linear variable, although the association of higher systolic BP and mortality in the faster walkers no longer reached statistical significance after adjustment for potential confounders (Table 4). In participants who did not complete the walk test, elevated systolic and diastolic BP were associated with a lower adjusted risk of mortality.

The estimates were robust against multiple sensitivity analyses, although there was limited power in several of these analyses (Figure 2). Finally, as an alternative classification of frail participants, we grouped the slower walkers and those who did not complete the walk for nonlogistical reasons; there was no association between higher systolic (HR, 1.00; 95% CI, 0.78-1.28) or diastolic (HR, 0.57; 95% CI, 0.23-1.40) BP and mortality in this lower-functioning group.



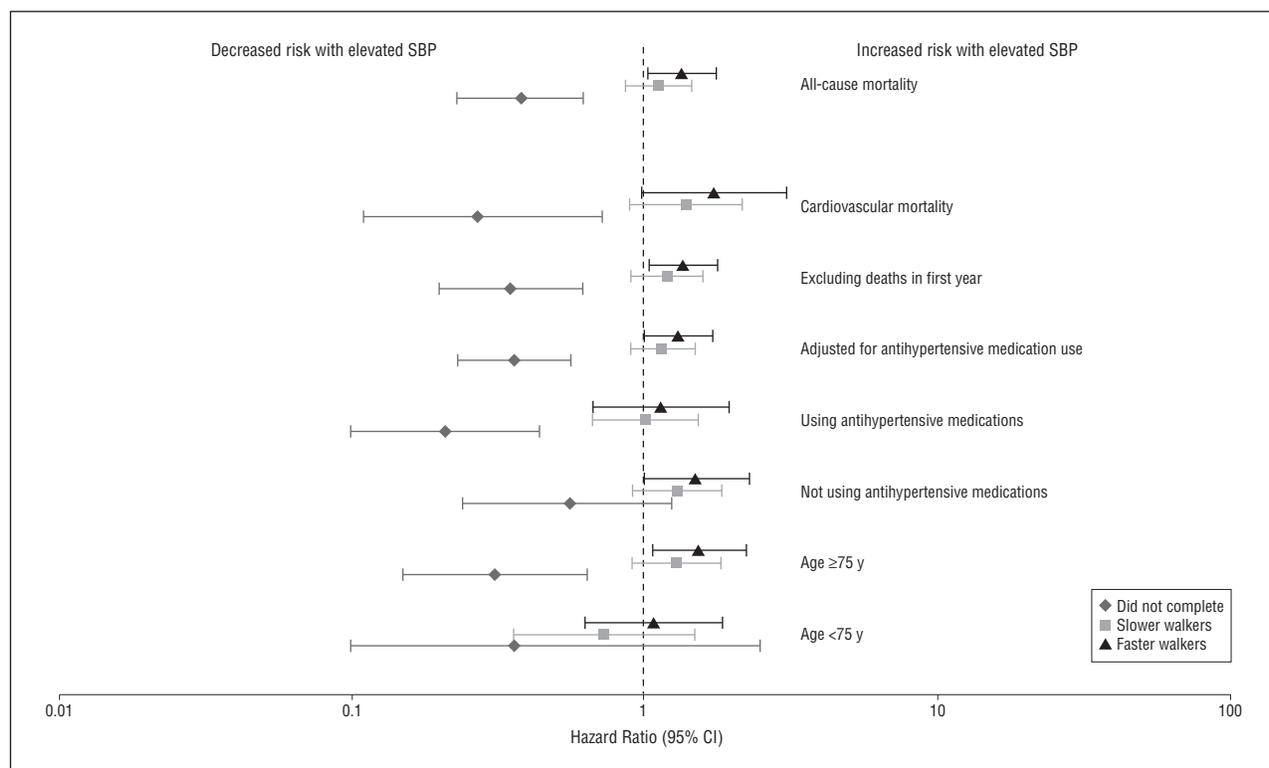
**Figure 1.** Kaplan-Meier survival plots. Kaplan-Meier survival plots of persons with elevated systolic blood pressure (SBP) 140 mm Hg or higher (A) and diastolic blood pressure (DBP) 90 mm Hg or higher (B), stratified by walking speed, in National Health and Nutrition Examination Survey participants 65 years and older (1999-2002), followed up until December 31, 2006

**Table 4. The Association of Linear Blood Pressure and Mortality, Stratified by Walking Speed, in NHANES Participants 65 Years and Older (1999-2002)**

BP	Walking Speed						P Value for Interaction
	Faster $\geq 0.8$ m/s		Slower $< 0.8$ m/s		Did Not Complete		
	HR (95% CI)	P Value	HR (95% CI)	P Value	HR (95% CI)	P Value	
Systolic BP, per 10 mm Hg higher							
Unadjusted	1.10 (1.01-1.21)	.03	1.04 (0.99-1.09)	.11	0.80 (0.73-0.87)	<.001	<.001
Adjusted <sup>a</sup>	1.10 (0.99-1.22)	.07	1.06 (1.01-1.11)	.02	0.75 (0.67-0.84)	<.001	<.001
Diastolic BP, per 10 mm Hg higher							
Unadjusted	0.97 (0.86-1.11)	.67	0.91 (0.82-1.02)	.10	0.70 (0.58-0.85)	.001	.03
Adjusted <sup>a</sup>	1.05 (0.92-1.20)	.44	0.95 (0.85-1.06)	.32	0.77 (0.60-0.98)	.04	.04

Abbreviations: BP, blood pressure; HR, hazard ratio; NHANES, National Health and Nutrition Examination Survey.

<sup>a</sup>Adjusted for survey year, age, sex, black race, education, smoking status, cholesterol level, coronary heart disease, heart failure, and stroke



**Figure 2.** Sensitivity analyses of the association of elevated systolic blood pressure (SBP) ( $\geq 140$  mm Hg) and mortality, stratified by walking speed, in National Health and Nutrition Examination Survey participants 65 years and older (1999-2002), followed up until December 31, 2006.

### COMMENT

In this nationally representative sample of elderly adults, we found that the association of BP with mortality varied by walking speed. Higher systolic BP was associated with an increased risk of mortality only among elderly adults who had a medium to fast walking pace. In contrast, among slower-walking older adults, there was not an association between elevated systolic or diastolic BP and mortality. Strikingly, we found elevated systolic and diastolic BP was strongly and independently associated with a *lower* mortality risk in participants who did not complete the walk test. Our findings suggest that walk-

ing speed may be a useful measure to identify older adults who are most at risk for the adverse effects of high BP.

Our findings are consistent with prior studies that have found that the association of BP and mortality diminishes with age<sup>7</sup> because the prevalence of frailty increases with age.<sup>18</sup> The present findings are also consistent with a recent study from our group.<sup>12</sup> We previously examined the relationship between BP, self-reported walking speed, and mortality in a cohort of older Latino adults. In participants who reported fast walking speed, there was an association of higher systolic BP with mortality, whereas there was no association in slower walkers. Latino adults may be at an increased risk for functional im-

pairment owing to the high prevalence of obesity and diabetes in this population. The present study extends our findings to a nationally representative study population and uses an objective measure of walking speed.

The association of elevated systolic BP and mortality in the faster walking elderly adults is also congruent with findings from randomized controlled trials that have demonstrated a benefit of treatment of antihypertensive therapy in study participants. Participants in trials are often healthier compared with the general population owing to study inclusion criteria that may limit the types and severity of comorbid conditions. In the Systolic Hypertension in the Elderly Program (SHEP), investigators reported a beneficial effect of antihypertensive therapy on stroke, major cardiovascular events, and all-cause mortality.<sup>19</sup> A large randomized controlled trial, the Hypertension in the Very Elderly Trial (HYVET), also demonstrated that persons 80 years and older who were receiving antihypertensive therapy had a reduced risk of all-cause mortality after 2 years of treatment.<sup>8</sup>

There has been substantial evidence published regarding the pathophysiologic consequences of hypertension in older adults.<sup>4</sup> Less literature has focused on the potential harm of lower BP, and the majority has focused on orthostatic hypotension as a risk factor for falls.<sup>4,20</sup> In older frail adults, elevated BP may be necessary to maintain perfusion of the vital organs, especially the heart, which is perfused during diastole.<sup>21</sup> This may explain the apparently protective association we observed between higher diastolic BP and lower mortality in participants who did not complete the walk test. Low diastolic BP may also contribute to high pulse pressure, which is a strong risk factor for coronary events in elderly adults.<sup>22</sup> Older frail adults may be at higher risk from aggressive therapeutic interventions, and our findings warrant further investigation of the effects of BP control in this population.

This finding of an inverted association between BP and mortality in those who did not complete the walk test was striking, although the wide range of reasons for not completing the walk precludes us from making any definitive conclusions regarding the mechanism for this inverted association in this population. There was a wide variety of comments regarding this missing data in the NHANES data, which included both logistical and safety reasons. Because only 243 participants had missing data, we did not have the statistical power to determine if the relation between BP and mortality differed within subgroups of these participants. On the basis of their baseline characteristics and mortality rate, the participants with missing walk test data appeared to have worse health status compared with those with complete data. Given the substantial difference in associations in those with and without walk test data, we suggest that future studies in older adults use methods to address this potential source of bias. Healthy participant bias is a well-described source of bias and may be of particular importance in older populations where frailty and disability are common.<sup>23</sup> This bias may help explain the apparently discordant findings between epidemiologic studies and randomized controlled trials of BP and antihypertensive medications in older adults.

This study also has limitations that should be considered. Both walking speed and BP often vary over time,

and because NHANES only had a 1-time measure of each, we were unable to account for changes in these factors over time. We assessed 1 domain of frailty, whereas the underlying process is complex and likely best assessed with a constellation of measures. In addition, many of the variables were self-reported, and there may be some misclassification of these measures. We classified walking speed into 2 levels to maximize statistical power within the strata, although the relationship between BP, walking speed, and mortality could likely be better described across multiple levels of walking speed in a larger study population.

In conclusion, this is the first study, to our knowledge, to examine the relationship between BP, walking speed, and mortality in a representative sample of US adults 65 years and older. We found that systolic BP is associated with an increased risk of mortality in adults with medium to fast walking speed. The association of BP and mortality is less clear in slower-walking adults, and future research should aim to characterize this relationship better in frail older adults and the institutionalized population. Some researchers have recommended that walking speed be incorporated into regular geriatric assessment as a predictive tool to identify those at risk for future adverse events and identify functional impairment in 1 or more of the systems that contribute to the ability to walk.<sup>11</sup> Walking speed appears to be a simple measure to explain the differential association of high BP and mortality in older adults.

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**Correspondence:** Michelle C. Odden, PhD, Oregon State University, 401 Waldo Hall, Corvallis, OR 97331 (Michelle.Odden@oregonstate.edu).

**Author Contributions:** Study concept and design: Odden, Peralta, Haan, and Covinsky. Acquisition of data: Odden. Analysis and interpretation of data: Odden, Peralta, Haan, and Covinsky. Drafting of the manuscript: Odden and Peralta. Critical revision of the manuscript for important intellectual content: Odden, Peralta, Haan, and Covinsky. Statistical analysis: Odden, Peralta, Haan, and Covinsky. Obtained funding: Odden. Administrative, technical, and material support: Odden. Study supervision: Odden. **Financial Disclosure:** None reported.

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## REFERENCES

1. Institute of Medicine Committee on Public Health Priorities to Reduce and Control Hypertension. *A Population-Based Policy and Systems Change Approach to Prevent and Control Hypertension*. Washington, DC: The National Academies Press; 2010.
2. Egan BM, Zhao Y, Axon RN, Brzezinski WA, Ferdinand KC. Uncontrolled and apparent treatment resistant hypertension in the United States, 1988 to 2008. *Circulation*. 2011;124(9):1046-1058.
3. Franklin SS, Gustin W IV, Wong ND, et al. Hemodynamic patterns of age-related

- changes in blood pressure: the Framingham Heart Study. *Circulation*. 1997; 96(1):308-315.
4. Aronow WS, Fleg JL, Pepine CJ, et al; ACCF Task Force. ACCF/AHA 2011 expert consensus document on hypertension in the elderly: a report of the American College of Cardiology Foundation Task Force on Clinical Expert Consensus Documents. *Circulation*. 2011;123(21):2434-2506.
  5. Chobanian AV, Bakris GL, Black HR, et al; Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. National Heart, Lung, and Blood Institute; National High Blood Pressure Education Program Coordinating Committee. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension*. 2003;42(6):1206-1252.
  6. Langer RD, Criqui MH, Barrett-Connor EL, Klauber MR, Ganiats TG. Blood pressure change and survival after age 75. *Hypertension*. 1993;22(4):551-559.
  7. Satish S, Freeman DH Jr, Ray L, Goodwin JS. The relationship between blood pressure and mortality in the oldest old. *J Am Geriatr Soc*. 2001;49(4):367-374.
  8. Beckett NS, Peters R, Fletcher AE, et al; HYVET Study Group. Treatment of hypertension in patients 80 years of age or older. *N Engl J Med*. 2008;358(18):1887-1898.
  9. Studenski S, Perera S, Patel K, et al. Gait speed and survival in older adults. *JAMA*. 2011;305(1):50-58.
  10. Abellan van Kan G, Rolland Y, Andrieu S, et al. Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people: an International Academy on Nutrition and Aging (IANA) Task Force. *J Nutr Health Aging*. 2009;13(10):881-889.
  11. Studenski S. Bradypedia: is gait speed ready for clinical use? *J Nutr Health Aging*. 2009;13(10):878-880.
  12. Odden MC, Covinsky KE, Neuhaus JM, Mayeda ER, Peralta CA, Haan MN. The association of blood pressure and mortality differs by self-reported walking speed in older Latinos [published online March 1, 2012]. *J Gerontol A Biol Sci Med Sci*. doi:10.1093/gerona/qlr245.
  13. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey. 2008. <http://www.cdc.gov/nchs/nhanes.htm>. Accessed August 25, 2008.
  14. Cooper R, Kuh D, Hardy R; Mortality Review Group; FALCon and HALCyon Study Teams. Objectively measured physical capability levels and mortality: systematic review and meta-analysis. *BMJ*. 2010;341:c4467.
  15. Purser JL, Kuchibhatla MN, Fillenbaum GG, Harding T, Peterson ED, Alexander KP. Identifying frailty in hospitalized older adults with significant coronary artery disease. *J Am Geriatr Soc*. 2006;54(11):1674-1681.
  16. Rothman MD, Leo-Summers L, Gill TM. Prognostic significance of potential frailty criteria. *J Am Geriatr Soc*. 2008;56(12):2211-1116.
  17. Stevens LA, Coresh J, Schmid CH, et al. Estimating GFR using serum cystatin C alone and in combination with serum creatinine: a pooled analysis of 3,418 individuals with CKD. *Am J Kidney Dis*. 2008;51(3):395-406.
  18. Fried LP, Tangen CM, Walston J, et al; Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*. 2001;56(3):M146-M156.
  19. SHEP Cooperative Research Group. Prevention of stroke by antihypertensive drug treatment in older persons with isolated systolic hypertension: final results of the Systolic Hypertension in the Elderly Program (SHEP). *JAMA*. 1991;265(24):3255-3264.
  20. Gupta V, Lipsitz LA. Orthostatic hypotension in the elderly: diagnosis and treatment. *Am J Med*. 2007;120(10):841-847.
  21. Goodwin JS. Embracing complexity: a consideration of hypertension in the very old. *J Gerontol A Biol Sci Med Sci*. 2003;58(7):653-658.
  22. Franklin SS, Lopez VA, Wong ND, et al. Single versus combined blood pressure components and risk for cardiovascular disease: the Framingham Heart Study. *Circulation*. 2009;119(2):243-250.
  23. Benfante R, Reed D, MacLean C, Kagan A. Response bias in the Honolulu Heart Program. *Am J Epidemiol*. 1989;130(6):1088-1100.

## INVITED COMMENTARY

# Gait Speed

## An Important Vital Sign in Old Age

In 1988, Matilla et al<sup>1</sup> reported that, among the very old, elevated systolic and diastolic blood pressure (BP) were associated with longer survival. The differences were not subtle. The 5-year survival of those with systolic BPs greater than 200 mm Hg were almost twice as high as those with levels of 120 to 140 mm Hg. Over the ensuing 25 years, a substantial number of population-based studies have reported the same findings: in those older than 85 years (or older than 80 years in some studies), high BP is an excellent prognostic sign.<sup>2,3</sup>

Perhaps the most rigorous assessment came from the Framingham Study, which reported that the strong positive association of BP with cardiovascular mortality was reversed between the ages of 75 and 85.<sup>4</sup> Importantly, no population-based study has found the opposite, that high BP is a marker for bad outcomes in octogenarians. Conversely, “normal” BP is bad. Perhaps the worst sign is falling BP.<sup>5</sup>

This set of observations has been one of the best-kept secrets in medicine. In my experience, many physicians find the information offensive and its proselytizers suspect. After all, the recognition and effective treatment of hypertension has been among the greatest medical and public health accomplishments of the latter 20th cen-

ture. Anyone with a message that threatens this progress might be dangerous.

Why might high BP be a good sign in those older than 80 years? Diehr and colleagues<sup>6</sup> noted that very old populations represent mixtures of those who are aging with those who are dying. They showed a steady decrease in BP in the 3 years before death in the very old. In other words, high BP is only a good sign in very old age because many of those with “normal” BP have it for bad reasons.

Additional evidence for this concept comes from longitudinal studies of somewhat younger populations. Several groups reported that higher levels of systolic or diastolic BP predicted lower mortality in those older than 70 years, but this relationship was eliminated and in some cases reversed if the analyses controlled for the presence of comorbidity, level of physical functioning, and other indicators of overall health status.<sup>2</sup> In this regard, normal levels of BP may be seen as a marker for frailty, and hypertension, a marker for robustness.

Another layer of complexity is added when we consider the question of treatment of hypertension in the very old. Of the 4 early randomized trials that included subjects older than 80 years, 3 reported interactions be-