Protective Health Factors and Incident Hypertension in Men

Jorge A. Banda[1,2], Kimberly Clouston[2], Xuemei Sui[2], Steven P. Hooker[1,2], Chong-Do Lee[3] and Steven N. Blair[2,4]

BACKGROUND
Few studies have examined the association between a combination of lifestyle factors and the incidence of hypertension, particularly among men. This is important as lifestyle factors are often interrelated, and may often occur in combination. Thus, we investigated the individual and combined effects of body mass index (BMI), smoking status, alcohol intake, physical activity (PA), and cardiorespiratory fitness (CRF) on the incidence of hypertension in men.

METHODS
A total of 14,568 men (mean age = 44.0 ± 9.3 years) from the Aerobics Center Longitudinal Study (ACLS) initially free of hypertension completed an extensive baseline examination during 1974–2003, and were followed for the incidence of hypertension.

RESULTS
A total of 1,959 men reported having hypertension during a mean of 10.7 ± 7.6 years of follow-up. Our data indicated that a combination of five protective health factors significantly reduced the risk of hypertension by 47% (95% confidence interval (CI): 36–56%). We also found that whether all participants in our sample had five protective health factors, the incidence of hypertension would be expected to decrease by 29% (95% CI: 26–31%). Additionally, having a normal BMI and being a nonsmoker and physically fit were significantly and independently associated with a lower risk of developing hypertension.

CONCLUSIONS
Our results show that among men aged 20–82 years, a healthy lifestyle can significantly reduce the risk of developing hypertension, and should be considered for the prevention of this chronic condition.

Keywords: *alcohol; blood pressure; body mass index; cardiorespiratory fitness; hypertension; physical activity ; smoking*

Am J Hypertens 2010; **23**:599-605 © 2010 American Journal of Hypertension, Ltd.

Hypertension is a common chronic condition among US adults, and represents a major public health problem. Despite prevention efforts, the prevalence of hypertension has increased by almost one-fourth over the past 15 years among adults in the United States, increasing from 22.2% in 1995 to 27.8% in 2007,[1,2] with estimated direct and indirect costs of hypertension totaling $73.4 billion in 2009.[3] This increasingly high prevalence is significant when one considers that hypertension is a risk factor for many adverse health conditions, including stroke, coronary heart disease, congestive heart failure, and renal disease.[4,5]

The research literature has consistently shown that lifestyle factors are associated with the incidence of hypertension. However, previous research has primarily investigated lifestyle factors individually, failing to fully examine the association between a combination of lifestyle factors and the incidence of hypertension. This is important when one considers that lifestyle factors are often interrelated. Recent research, including our own work, has begun to explore the association between a combination of lifestyle factors and adverse health conditions and outcomes.[6–11] These studies have led to a better understanding of the etiology of diseases such as coronary heart disease,[12] stroke,[8] diabetes,[9] and cancer,[10] and have the potential to improve primary prevention efforts.

A recent report from the Nurses' Health Study shows that having more low-risk lifestyle factors can significantly reduce the risk of developing hypertension among women.[13] However, sample characteristics, and the inclusion of lifestyle factors such folic acid use, limit the study's generalizability toward men. Recent surveillance data indicate that men are a high-risk group for hypertension, with the prevalence of hypertension being higher among men (28.1%) than in women (26.4%), and with prevalence rates increasing at a faster rate as well.[2] Examining the association between individual and combined lifestyle factors and the incidence of hypertension among men would lead to a better understanding of the etiology of hypertension, and has the potential to contribute to improved prevention and treatment strategies. Thus, the purpose of this study was to investigate the individual and combined effect

[1]Prevention Research Center, University of South Carolina, Columbia, South Carolina, USA; [2]Department of Exercise Science, University of South Carolina, Columbia, South Carolina, USA; [3]Department of Exercise and Wellness, Arizona State University, Mesa, Arizona, USA; [4]Department of Epidemiology and Biostatistics, University of South Carolina, Columbia, South Carolina, USA. Correspondence: Jorge A. Banda (Bandaj@email.sc.edu)

Received 3 November 2009; first decision 3 December 2009; accepted 1 February 2010; advance online publication 11 March 2010. doi:10.1038/ajh.2010.26

of body mass index (BMI), smoking status, alcohol intake, physical activity (PA), and cardiorespiratory fitness (CRF) on the incidence of hypertension in men.

METHODS

Study population. The Aerobics Center Longitudinal Study (ACLS) is a cohort study that examines the relationship of PA, CRF, and other factors to health-related conditions and outcomes.[14] Study participants came to the Cooper Clinic (Dallas, TX) for periodic preventive health examinations and counseling regarding diet, exercise, and other lifestyle factors associated with an increased risk of chronic disease. Although many participants were sent to the examination by their employers, some were referred by their personal physicians, whereas others were self-referred.

The present study consists of 14,568 men aged 20–82 years who completed a baseline examination at the Cooper Clinic during 1974–2003. The sample was predominantly white, well-educated, and from the middle and upper socioeconomic strata. At baseline, all participants included in the analysis were free of known cardiovascular disease and cancer, had a BMI $\geq 18.5\,kg/m^2$, and achieved an 85% age-predicted maximal heart rate (220 − age) during a gradual exercise treadmill test. Participants also reported no physician diagnosis of hypertension and had a resting blood pressure of <140/90 mm Hg at baseline. The study protocol was approved annually by the institutional review board of the Cooper Institute and the procedures used in the study were in accordance with institutional guidelines.

Baseline examination. The baseline clinical examination was conducted after receiving written informed consent from each participant, and included fasting blood chemistry analyses, personal and family health history, anthropometry, resting blood pressure, and an electrocardiogram. Previous studies have described the baseline examination in detail.[14–16] Briefly, resting blood pressure was measured in the seated position, and was recorded as the first and fifth Korotkoff sounds by auscultatory methods after at least 5 min of sitting quietly. Resting blood pressure was measured twice, with readings separated by 2 min. If the first two readings differed by >5 mm Hg, additional readings were obtained. The average of the readings was used to determine baseline resting blood pressure. Body weight and height were measured with a standard physician's scale and a stadiometer, and were used to determine BMI.

Serum samples were analyzed using standardized automated bioassays. Diabetes mellitus was defined as fasting plasma glucose levels ≥126 mg/dl or a history of physician-diagnosed diabetes mellitus. Information on smoking habits (never, former, or current smoker), alcohol intake (drinks per week), PA, and a family history of hypertension were obtained from a standardized questionnaire. All procedures were administered by trained technicians who followed standardized protocols.

PA was self-reported, with participants completing a series of questions about their usual patterns of PA in the 3 months before the examination. Their responses allowed for the creation of a PA index, allowing for PA to be categorized into low (no activity), moderate (walking, jogging, or running up to 10 miles/week or participating in sporting or leisure-time physical activities other than walking, jogging, or running) and high (walking, jogging, or running >10 miles/week) activity.[17] CRF was measured by a maximal treadmill exercise test as described previously.[14,15] Total treadmill endurance time (minutes) was used as an index of aerobic power, with time on the treadmill in this protocol correlated highly ($r > 0.92$) with maximal oxygen uptake (VO_{2max}) in men.[18] Participants were classified into low-third, middle-third, and high-third groups based on age-specific tertiles of treadmill time.

Protective health profile. A protective health profile was characterized by the following health factors: light alcohol consumption (1–14 drinks per week), physically active (participants who did not indicate any activities in the prior 3 months were classified as physically inactive, all others were classified active), physically fit (middle and high tertiles of CRF), normal weight (BMI between 18.5 and 24.9 kg/m^2), and not a current smoker. Based on criteria met, categories of 0, 1, 2, 3, 4, and 5 combined protective health factors were formed.

Ascertainment of hypertension. The incidence of hypertension was ascertained from responses to mail-back health surveys in 1982, 1986, 1990, 1999, and 2004. Data were not available in 1995 due to the hypertension question not being included in the mail-back health survey. Participants were asked whether a physician had ever told them they had hypertension. If they had, responders were asked to report the year of diagnosis. For those who completed multiple surveys, the first survey in which hypertension was reported was used in the analyses. The cumulative response rate across all survey periods in the ACLS is ~65%.[16,19] Nonresponse bias has been investigated in the ACLS, and was found not to present a major source of bias.[20] This method of case ascertainment is similar to those used in other well-known epidemiological studies.[21–23] We previously verified the accuracy of reported hypertension events in this cohort as 98% sensitivity and 99% specificity.[15]

Statistical analysis. Follow-up time was calculated from the date of the baseline examination until the date of the first hypertension event, or 1 June 2004, whichever came first. General linear models were used to test mean differences across number of health-risk factors. A χ^2-test was used to compare frequency differences across the number of health factors. Hazard ratios and 95% confidence intervals (CIs) were estimated using Cox proportional hazards models adjusting for examination year and survey response patterns, along with participant characteristics and confounding variables, including age, baseline resting systolic and diastolic blood pressure, diabetes, family history of hypertension, and the presence of other health factors. Adjusting for survey response patterns and baseline examination year are standardized ACLS approaches when identifying outcomes from multiple mail-back surveys.[24–26] Further, the ACLS is an open cohort study with participants entering the study at different times. As a result, it's important to adjust for baseline examination year to account for this variation. Inspection of empirical cumulative hazards plots (log–log (survival function) vs. log (time) across number of health-risk factors) indicated that the proportional hazards assumption was justified. Population attributable risk of hypertension was estimated for the five protective health factors.[27] Kaplan–Meier survival curves were constructed to compare the probability of hypertension events across number of protective health factors. All statistical analyses were performed by Statistical Analysis Systems Software (SAS Institute, Cary, NC) and all *P* values are two-sided, with an α-level of 0.05.

RESULTS

There were 1,959 incident cases of hypertension after a mean of 10.7 ± 7.6 years of follow-up of the 14,568 participants. Table 1 shows baseline characteristics of study participants across several modifiable health factors. Study participants were middle-aged (44.0 ± 9.3 years), typically overweight (25.5 ± 3.7 kg/m^2), and predominantly physically active (75.2%) and nonsmokers (83.4%). The results showed that participants who had a greater number of protective health factors were more likely to have a lower BMI, lower systolic and diastolic blood pressure, lower total cholesterol, and a lower fasting glucose (P_{trend} < 0.0001).

Tables 2 and 3 show the association between individual protective health factors and the incidence of hypertension after adjusting for age and examination year (model 1), further adjusting for survey response pattern, resting blood pressure, diabetes, and a family history of hypertension (model 2), and further adjusting for each of the other protective health factors (model 3). We found that BMI, smoking status, and CRF (models 1, 2, and 3 in Tables 2 and 3) were significantly and independently associated with the incidence of hypertension. Specifically, normal weight individuals had a lower risk of developing hypertension when compared with overweight and obese individuals (hazard ratio: 0.75; 95% CI: 0.69–0.83), noncurrent smokers had a lower risk of developing hypertension when compared with current smokers (hazard ratio: 0.75; 95%

Table 1 | Participant baseline characteristics across number of health factors

Characteristic	All	Number of health factors 0	1	2	3	4	5	P_{trend}
Number of participants	14,568	176	1,085	2,306	3,526	4,584	2,891	
Age (years)	44.0 ± 9.3	44.2 ± 8.8	44.2 ± 8.6	44.6 ± 9.3	44.8 ± 9.3	44.0 ± 9.3	42.7 ± 9.4	<0.0001
Body mass index (kg/m^2)	25.5 ± 3.7	28.0 ± 2.7	27.7 ± 3.3	27.1 ± 6.0	26.4 ± 3.0	25.0 ± 2.5	23.1 ± 1.3	<0.0001
Metabolic equivalents (METs)	12.2 ± 2.4	9.2 ± 1.3	9.6 ± 1.3	10.2 ± 1.4	11.5 ± 1.8	13.1 ± 2.0	14.2 ± 2.1	<0.0001
Systolic blood pressure (mm Hg)	117.0 ± 9.0	118.0 ± 9.0	117.0 ± 9.0	117.0 ± 9.0	117.0 ± 9.0	117.0 ± 10.0	116.0 ± 10.0	<0.0001
Diastolic blood pressure (mm Hg)	77.0 ± 7.0	78.0 ± 6.0	78.0 ± 7.0	78.0 ± 6.0	78.0 ± 6.0	77.0 ± 7.0	76.0 ± 7.0	<0.0001
Total cholesterol (mg/dl)	205.3 ± 37.4	214.2 ± 33.1	215.3 ± 38.2	211.5 ± 38.0	208.8 ± 38.1	202.2 ± 36.7	196.4 ± 34.8	<0.0001
Fasting glucose (mg/dl)	98.5 ± 14.2	101.2 ± 16.2	101.5 ± 20.3	99.9 ± 18.1	98.8 ± 12.5	97.9 ± 12.9	96.5 ± 10.8	<0.0001
Smoking status (%)								<0.0001
Never smoker	48.8	0.0	22.5	37.9	47.1	56.5	60.5	
Former smoker	34.6	0.0	20.2	32.5	35.3	36.7	39.5	
Current smoker	16.6	100.0	57.3	29.6	17.6	6.8	0.0	
Alcohol intake (drinks/week)	4.3 ± 6.1	4.9 ± 10.9	4.2 ± 8.2	4.0 ± 6.8	4.4 ± 6.7	4.3 ± 5.7	4.6 ± 3.5	<0.0001
Physical activity (%)[a]								<0.0001
Low	24.8	100.0	86.5	58.3	23.8	6.7	0.0	
Moderate	53.4	0.0	13.1	36.9	60.5	63.2	60.5	
High	21.8	0.0	0.4	4.8	15.7	30.1	39.5	
Diabetes (%)[b]	3.8	7.4	6.4	5.6	3.9	2.9	2.7	<0.0001
Family history of hypertension (%)	11.6	4.0	8.1	8.8	11.9	12.6	13.7	<0.0001

[a]Physical activity was categorized into low (no activity), moderate (walking, jogging, or running up to 10 miles/week or participating in sporting or leisure-time physical activities other than walking, jogging, or running), and high (walking, jogging, or running >10 miles/week) activity. [b]Diabetes mellitus was defined as fasting plasma glucose levels ≥126 mg/dl or a history of physician-diagnosed diabetes mellitus.

Table 2 | Cox proportional hazard ratios for individual health factors and risk of incident hypertension

			Model 1[a]	Model 2[b]	Model 3[c]
Health factor	Number at risk	Number of cases	HR (95% CI)	HR (95% CI)	HR (95% CI)
Body mass index					
Normal weight (18.5–24.9 kg/m^2)	6,992	817	0.43 (0.37–0.51)	0.54 (0.46–0.63)	0.60 (0.51–0.71)
Overweight (25.0–29.9 kg/m^2)	6,441	934	0.64 (0.55–0.74)	0.73 (0.63–0.85)	0.77 (0.66–0.90)
Obese (≥30.0 kg/m^2)	1,135	208	1.00	1.00	1.00
Smoking					
Never smoker	7,115	828	0.73 (0.64–0.82)	0.68 (0.60–0.77)	0.72 (0.64–0.82)
Past smoker	5,038	756	0.78 (0.68–0.88)	0.74 (0.65–0.84)	0.78 (0.68–0.88)
Current smoker	2,415	375	1.00	1.00	1.00
Alcohol intake (drinks per week)					
None	4,297	705	0.99 (0.90–1.09)	0.98 (0.89–1.07)	0.98 (0.89–1.08)
Light (1–14)	9,318	1,132	1.18 (0.97–1.43)	1.10 (0.90–1.33)	1.08 (0.88–1.31)
Moderate and heavy (>14)	953	122	1.00	1.00	1.00
Physical activity[d]					
High	3,190	368	0.76 (0.67–0.87)	0.78 (0.68–0.89)	1.01 (0.87–1.17)
Moderate	7,772	1,015	0.87 (0.79–0.97)	0.90 (0.82–1.00)	1.04 (0.93–1.17)
Low	3,606	576	1.00	1.00	1.00
Cardiorespiratory fitness[e]					
High third	4,841	495	0.58 (0.52–0.65)	0.62 (0.55–0.69)	0.69 (0.60–0.78)
Middle third	4,800	640	0.80 (0.72–0.88)	0.82 (0.74–0.91)	0.86 (0.77–0.96)
Low third	4,927	824	1.00	1.00	1.00

CI, confidence interval; HR, hazard ratio.
[a]Adjusted for age (single year) and examination year. [b]Adjusted for variables in model 1 plus survey response pattern, resting systolic and diastolic blood pressure, diabetes, and family history of hypertension. [c]Adjusted for variables in model 2 plus each of the other variables in the table. [d]See **Table 1**. [e]Participants were categorized into groups based on age-specific tertiles of treadmill time.

CI of 0.67–0.84), and physically fit individuals had a lower risk of developing hypertension when compared with those who were physically unfit (hazard ratio: 0.79; 95% CI: 0.71–0.88) (model 3 in **Table 3**).

Table 4 depicts the rate of hypertension across the number of protective health factors at baseline. After adjusting for multiple factors (model 2), it was found that a combination of five protective health factors significantly reduced the risk of hypertension by 47% (95% CI: 36–56%) when compared with zero to one health factors. Additionally, if all participants in our sample had five protective health factors, the population attributable risk results indicate that the incidence of hypertension would be expected to decrease by 29% (95% CI: 26–31%). **Figure 1** displays Kaplan–Meier curves for the number of protective health factors. The corresponding log-rank test statistic was 81.79, $P < 0.0001$.

DISCUSSION

The results demonstrated that protective health factors, both in combination and individually, significantly reduced the risk of developing hypertension among a group of men over an average period of nearly 11 years. Our data indicated that having five protective health factors significantly reduced the risk of hypertension in our sample by 47%. We also found

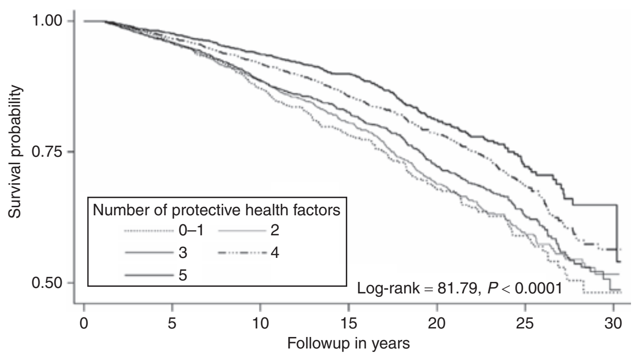

Figure 1 | Kaplan–Meier curves for incident hypertension by number of protective health factors.

that whether all participants in our sample had five protective health factors, the incidence of hypertension would be expected to decrease by 29%. Although many studies have examined the combined effect of protective health factors on adverse health conditions and outcomes,[6–11,13,28–30] few have investigated this relationship in hypertension.

In a 14-year longitudinal study by the Nurses' Health Study in the United States, having six low-risk factors resulted in a 78% decrease in the risk of developing hypertension, and a population attributable risk of 78%.[13] Additionally, in a

Table 3 | Cox proportional hazard ratios comparing low-risk to high-risk groups for incident hypertension

Health factor	Number at risk	Number of cases	Model 1[a] HR (95% CI)	Model 2[b] HR (95% CI)	Model 3[c] HR (95% CI)
Body mass index[d]					
Normal weight vs. overweight and obese	6,992	817	0.64 (0.58–0.70)	0.71 (0.64–0.77)	0.75 (0.69–0.83)
Smoking status					
Noncurrent vs. current	12,153	1,584	0.75 (0.67–0.84)	0.71 (0.63–0.79)	0.75 (0.67–0.84)
Alcohol intake (drinks per week)[d]					
Light vs. none and moderate and heavy	9,318	1,132	0.97 (0.88–1.06)	0.96 (0.88–1.05)	0.97 (0.88–1.06)
Physical activity[e]					
Physically active vs. physically inactive	10,962	1,383	0.84 (0.76–0.93)	0.87 (0.79–0.96)	1.04 (0.93–1.16)
Cardiorespiratory fitness[f]					
Physically fit vs. Physically unfit	9,641	1,135	0.69 (0.63–0.76)	0.72 (0.66–0.79)	0.79 (0.71–0.88)

CI, confidence interval; HR, hazard ratio.
[a]Adjusted for age (single year) and examination year. [b]Adjusted for variables in model 1 plus survey response pattern, resting systolic and diastolic blood pressure, diabetes, and family history of hypertension. [c]Adjusted for variables in model 2 plus each of the other variables in the table. [d]See **Table 2**. Noncurrent was defined as never smoker and former smoker, and current is defined as current smoker. [e]Physically inactive was defined as participants who did not indicate any activities in the prior 3 months; all other participants were classified as physically active. [f]Physically unfit was defined as the lowest age-specific tertile of treadmill time, and physically fit was defined as the upper two age-specific tertiles of treadmill time.

Table 4 | Cox proportional hazard ratios of the combined protective health factors and incident hypertension

Number of protective health factors	Cases	Rate[a]	Model 1[b] HR (95% CI)	Model 2[c] HR (95% CI)
0–1	224	176.4	1.00	1.00
2	418	159.5	0.90 (0.77–1.06)	0.92 (0.78–1.08)
3	516	139.0	0.79 (0.67–0.92)	0.81 (0.69–0.95)
4	530	107.6	0.61 (0.52–0.71)	0.65 (0.55–0.76)
5	271	86.6	0.49 (0.41–0.59)	0.53 (0.44–0.64)
P_{trend}		<0.0001	<0.0001	<0.0001

CI, confidence interval; HR, hazard ratio.
[a]Rate per 10,000 person-years adjusted for age and examination year. [b]Adjusted for age (single year) and examination year. [c]Adjusted for variables in model 1 plus survey response pattern, resting systolic and diastolic blood pressure, diabetes, and family history of hypertension.

cross-sectional study among 1,018 Irish men and women aged 50–69 years, the Cork and Kerry Diabetes and Heart Study in the UK found that having four or more protective lifestyle factors was associated with a 69% decrease in the risk of having hypertension.[30] The Okinawa General Health Maintenance Association found similar results among 4,857 Japanese men and women aged 46 ± 9 years, as individuals with one risk factor had a 1.43 times greater risk of developing hypertension at a 2-year follow-up.[28]

Although the results of these previous studies offer an important contribution to the research literature, we feel our prospective design with long follow-up offers important additional information on health factors and hypertension risk, and that our sample offers greater generalizability to US adults, particularly men. Additionally, the inclusion of population attributable risk in our analysis, which has not been fully explored when examining the effect of multiple protective health factors on the incidence of hypertension among men, provides more information on the risk reduction possible by the addition of protective health factors.

The present study also found that BMI, smoking status, and CRF were independently associated with a reduced risk of developing hypertension, with individual risk reductions ranging from 21 to 25%. These results are similar to previous research findings, which have shown that BMI, smoking status, and CRF are independently associated with the risk of hypertension.[13,15,16,21,24,30–34] Recent surveillance data indicate that 70.8% of men in the United States are either overweight or obese[35] and 20.3% are current smokers.[2] Given these high proportions, efforts to decrease the prevalence of overweight and obesity, and programs focusing on smoking cessation and improving CRF, have the potential to significantly reduce the risk and incidence of hypertension among men.

Strengths of the present study include a relatively large sample size (N = 14,568) and a follow-up period of 10.7 ± 7.6 years. Additionally, the present study included an extensive baseline examination, including objectively measured blood pressure, BMI, and CRF. Finally, our statistical analysis extensively adjusted for potential confounders. There are some limitations that should be considered when interpreting the results of the present study. First, the homogeneity of the ACLS population on sociodemographic factors deserves comment. The sample was comprised of men who were mainly white, of middle to upper class socioeconomic status, and relatively fit and physically active. Although this enhances the internal validity of our findings by reducing the degree of confounding by these factors, our findings may not generalize well to the general population. Second, many of the health factors used in this study were self-reported, such as PA, alcohol consumption, and smoking status. However, although there are biases associated with self-report measures, they were minimized as much as possible by using standardized procedures and validated instruments. Finally, because of widespread geographical distribution of participants, we were unable to verify the time of onset of hypertension in all cases. However, it appears that an acceptable level of agreement exists between the participant's self-report histories and their medical records based on a validation substudy.[15,19,24]

Our results indicate that a healthy lifestyle can significantly reduce the risk of developing hypertension, with substantial decreases in the incidence of hypertension possible on a population level. Recent research has indicated that while high-risk hypertensive patients receive high rates of lifestyle counseling, gaps exist for lifestyle counseling for young and low-risk hypertensive patients.[36] Based on these results, it's our recommendation that clinicians and public health professionals incorporate lifestyle modification counseling into the management of hypertension for both primary and secondary prevention. In conclusion, the combination of multiple protective health factors lowered the risk and incidence of hypertension, and should be considered for the prevention of this chronic disease.

Acknowledgments: The ACLS was supported by NIH grants AG06945 and HL62508. We thank the Cooper Clinic physicians and technicians for collecting the baseline data, and staff at the Cooper Institute for data entry and data management.

Disclosure: The authors declared no conflict of interest.

1. Centers for Disease Control and Prevention (CDC). *Behavioral Risk Factor Surveillance System Survey Data*. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention: Atlanta, Georgia, 1995.
2. Centers for Disease Control and Prevention (CDC). *Behavioral Risk Factor Surveillance System Survey Data*. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention: Atlanta, Georgia, 2007.
3. American Heart Association. *Heart Disease and Stroke Statistics – 2008 Update*. American Heart Association: Dallas, TX, 2008.
4. Vasan RS, Larson MG, Leip EP, Evans JC, O'Donnell CJ, Kannel WB, Levy D. Impact of high-normal blood pressure on the risk of cardiovascular disease. *N Engl J Med* 2001; 345:1291–1297.
5. American Heart Association. Why should I care? <http://www.americanheart.org/presenter.jhtml?identifier=2129>. Accessed 26 April 2009.
6. Knoops KT, de Groot LC, Kromhout D, Perrin AE, Moreiras-Varela O, Menotti A, van Staveren WA. Mediterranean diet, lifestyle factors, and 10-year mortality in elderly European men and women: the HALE project. *JAMA* 2004; 292: 1433–1439.
7. Chiuve SE, McCullough ML, Sacks FM, Rimm EB. Healthy lifestyle factors in the primary prevention of coronary heart disease among men: benefits among users and nonusers of lipid-lowering and antihypertensive medications. *Circulation* 2006; 114:160–167.
8. Kurth T, Moore SC, Gaziano JM, Kase CS, Stampfer MJ, Berger K, Buring JE. Healthy lifestyle and the risk of stroke in women. *Arch Intern Med* 2006; 166:1403–1409.
9. Mozaffarian D, Kamineni A, Carnethon M, Djoussé L, Mukamal KJ, Siscovick D. Lifestyle risk factors and new-onset diabetes mellitus in older adults: the cardiovascular health study. *Arch Intern Med* 2009; 169:798–807.
10. Jiao L, Mitrou PN, Reedy J, Graubard BI, Hollenbeck AR, Schatzkin A, Stolzenberg-Solomon R. A combined healthy lifestyle score and risk of pancreatic cancer in a large cohort study. *Arch Intern Med* 2009; 169: 764–770.
11. Lee CD, Sui X, Blair SN. Combined effects of cardiorespiratory fitness, not smoking, and normal waist girth on morbidity and mortality in men. *Arch Intern Med* 2009; 169:2096–2101.
12. Chiuve SE, Rexrode KM, Spiegelman D, Logroscino G, Manson JE, Rimm EB. Primary prevention of stroke by healthy lifestyle. *Circulation* 2008; 118: 947–954.
13. Forman JP, Stampfer MJ, Curhan GC. Diet and lifestyle risk factors associated with incident hypertension in women. *JAMA* 2009; 302:401–411.
14. Blair SN, Kohl HW 3rd, Paffenbarger RS Jr, Clark DG, Cooper KH, Gibbons LW. Physical fitness and all-cause mortality. A prospective study of healthy men and women. *JAMA* 1989; 262:2395–2401.
15. Blair SN, Goodyear NN, Gibbons LW, Cooper KH. Physical fitness and incidence of hypertension in healthy normotensive men and women. *JAMA* 1984; 252: 487–490.
16. Shuger SL, Sui X, Church TS, Meriwether RA, Blair SN. Body mass index as a predictor of hypertension incidence among initially healthy normotensive women. *Am J Hypertens* 2008; 21:613–619.
17. Kampert JB, Blair SN, Barlow CE, Kohl HW 3rd. Physical activity, physical fitness, and all-cause and cancer mortality: a prospective study of men and women. *Ann Epidemiol* 1996; 6:452–457.
18. Pollock ML, Bohannon RL, Cooper KH, Ayres JJ, Ward A, White SR, Linnerud AC. A comparative analysis of four protocols for maximal treadmill stress testing. *Am Heart J* 1976; 92:39–46.
19. Sui X, LaMonte MJ, Blair SN. Cardiorespiratory fitness and risk of nonfatal cardiovascular disease in women and men with hypertension. *Am J Hypertens* 2007; 20:608–615.
20. Macera CA, Jackson KL, Davis DR, Kronenfeld JJ, Blair SN. Patterns of non-response to a mail survey. *J Clin Epidemiol* 1990; 43:1427–1430.
21. Gelber RP, Gaziano JM, Manson JE, Buring JE, Sesso HD. A prospective study of body mass index and the risk of developing hypertension in men. *Am J Hypertens* 2007; 20:370–377.
22. Huang Z, Willett WC, Manson JE, Rosner B, Stampfer MJ, Speizer FE, Colditz GA. Body weight, weight change, and risk for hypertension in women. *Ann Intern Med* 1998; 128:81–88.
23. Paffenbarger RS Jr, Wing AL, Hyde RT, Jung DL. Physical activity and incidence of hypertension in college alumni. *Am J Epidemiol* 1983; 117:245–257.
24. Barlow CE, LaMonte MJ, Fitzgerald SJ, Kampert JB, Perrin JL, Blair SN. Cardiorespiratory fitness is an independent predictor of hypertension incidence among initially normotensive healthy women. *Am J Epidemiol* 2006; 163:142–150.
25. Chase NL, Sui X, Lee DC, Blair SN. The association of cardiorespiratory fitness and physical activity with incidence of hypertension in men. *Am J Hypertens* 2009; 22:417–424.
26. Maslow AL, Sui X, Colabianchi N, Hussey J, Blair SN. Muscular strength and incident hypertension in normotensive and prehypertensive men. *Med Sci Sports Exerc* 2010; 42:288–295.
27. Bruzzi P, Green SB, Byar DP, Brinton LA, Schairer C. Estimating the population attributable risk for multiple risk factors using case-control data. *Am J Epidemiol* 1985; 122:904–914.
28. Tozawa M, Iseki K, Iseki C, Oshiro S, Higashiuesato Y, Ikemiya Y, Takishita S. Impact of multiple risk factor clustering on the elevation of blood pressure. *Hypertens Res* 2002; 25:811–816.
29. Tozawa M, Oshiro S, Iseki C, Sesoko S, Higashiuesato Y, Tana T, Ikemiya Y, Iseki K, Fukiyama K. Multiple risk factor clustering of hypertension in a screened cohort. *J Hypertens* 2000; 18:1379–1385.
30. Villegas R, Kearney PM, Perry IJ. The cumulative effect of core lifestyle behaviours on the prevalence of hypertension and dyslipidemia. *BMC Public Health* 2008; 8:210.

31. Rankinen T, Church TS, Rice T, Bouchard C, Blair SN. Cardiorespiratory fitness, BMI, and risk of hypertension: the HYPGENE study. *Med Sci Sports Exerc* 2007; 39:1687–1692.
32. Halimi JM, Giraudeau B, Vol S, Cacès E, Nivet H, Tichet J. The risk of hypertension in men: direct and indirect effects of chronic smoking. *J Hypertens* 2002; 20: 187–193.
33. Halperin RO, Gaziano JM, Sesso HD. Smoking and the risk of incident hypertension in middle-aged and older men. *Am J Hypertens* 2008; 21: 148–152.
34. Radi S, Lang T, Lauwers-Cancès V, Chatellier G, Fauvel JP, Larabi L, De Gaudemaris R; IHPAF Group. One-year hypertension incidence and its predictors in a working population: the IHPAF study. *J Hum Hypertens* 2004; 18:487–494.
35. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. *JAMA* 2006; 295:1549–1555.
36. Lopez L, Cook EF, Horng MS, Hicks LS. Lifestyle modification counseling for hypertensive patients: results from the National Health and Nutrition Examination Survey 1999–2004. *Am J Hypertens* 2009; 22:325–331.