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Ankle brachial index screening in asymptomatic older adults

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Abstract

Background—Screening for peripheral arterial disease (PAD) by measuring ankle brachial index (ABI) in asymptomatic older adults is currently recommended to improve cardiovascular disease risk assessment and establish early treatment, but it is not clear if the strategy is useful in all populations. We examined the prevalence and independent predictors of an abnormal ABI (<0.90), in an asymptomatic sample of 1,017 adults, 60 to 69 years old, enrolled in the ADVANCE study.

Methods—Baseline data collected between December 2001 and January 2004 among the healthy older controls enrolled in ADVANCE was examined. Frequency distributions and prevalence estimates of an abnormal ABI were calculated, using both standard and modified definitions of ABI. Stepwise logistic regression was used to examine independent predictors of ABI <0.90 . Signal detection analysis using recursive partitioning was employed to explore potential demographic and clinical variables related to ABI <0.90 .

Results—The prevalence of ABI <0.90 was 2% when using the standard definition and 5% when using a modified definition. ABI prevalence did not differ by gender ($P > .05$). Compared with subjects who had a normal ABI (0.90–1.39), subjects with an ABI <0.90 were more likely to currently smoke, be physically inactive, have a coronary artery calcium score >10 , and an FRS $>20\%$ ($P = .02$). Independent predictors of ABI <0.90 when using the standard definition included currently smoking, physical inactivity, and body mass index >30 (all P values $< .03$), and when using the modified definition included currently smoking, physical inactivity, and hypertension

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(all P values $\leq .04$). Currently, smoking was the only significant variable for ABI <0.90 derived through recursive partitioning ($P = .02$), and indicated that prevalence of ABI <0.90 was 1.5% for nonsmokers, while it was 6.6% for current smokers.

Conclusions—ABI screening in generally healthy individuals 60 to 69 years old may result in lower prevalence rates of a positive result than estimates based on studies in clinical populations. The modified definition for calculating ABI captured more asymptomatic adults with suspected peripheral arterial disease. More evaluation of the appropriate role of ABI screening in unselected populations is needed before routine screening is implemented.

Evidence that adults with peripheral arterial disease (PAD) in the lower extremities are at higher risk for a cardiovascular disease (CVD) event, such as myocardial infarction or stroke, is clearly established.¹ The American College of Cardiology/American Heart Association 2005 Practice Guidelines for the management of patients with PAD recommend measurement of ankle brachial index (ABI) in asymptomatic adults ≥ 50 years old with history of smoking or diabetes, among adults with lower extremity circulation problems, and all adults ≥ 70 years old to improve CVD risk assessment and establish early treatment.¹ The recent Ankle Brachial Index Collaboration meta-analysis² suggests that measurement of ABI may improve CVD risk prediction beyond the Framingham risk score. On the other hand, the United States Preventive Services Task Force recommends against routine ABI screening in asymptomatic adults, citing that there is insufficient evidence to warrant routine screening and that the added costs in time and resources may exceed benefits.³

Routine screening tests are most useful when they reduce mortality or morbidity. The elements of a good screening test include its ability to detect a subclinical phase of the disease, when early treatment is known to improve patient outcomes, and to be widely accessible, simple to administer, inexpensive, and associated with minimal discomfort and morbidity for the population to be screened.⁴ Further, it is paramount that a screening test has established strong sensitivity and specificity for the disease being screened, for example, an ABI for detecting PAD.^{5,6} Reported sensitivity and specificity of ABI <0.90 to detect $\geq 50\%$ stenosis in the lower extremities using digital subtraction angiography, is 76% and 90%, respectively.⁷

In 2003, the average US cost of performing an ABI was \$61 per case.⁸ Yet, ABI screening among adults at higher risk for developing PAD also uses resources such as staff training and time, equipment and supplies. Campbell et al⁹ conducted a study to improve targeted screening efforts for identifying PAD in high risk persons and reported associated costs ranging from 1 to 3 days of staff time per diagnosis.⁹ In addition, these investigators estimated that 15 patients needed to be screened to detect one new patient with PAD.⁹

Reported prevalence of PAD, using ABI <0.90 as the indicator, ranges from 1.2% in a managed care organization's population of 6.67 million adult members ≥ 18 years old,¹⁰ up to 29% in the PARTNERS study which enrolled only higher-risk adults, that is, 50 to 69 years old with a history of smoking or diabetes mellitus or adults at least 70 years old.¹¹ It is unknown what the prevalence of PAD (using ABI <0.90) is among healthy adults 60 to 69 years old without documented clinical cardiovascular disease.

Another issue for determining prevalence estimates of PAD using ABI <0.90 as the indicator, are the various methods reported for calculating ABI.¹² The standard method uses the highest ankle pressure for each leg, divided by the highest brachial pressure.^{13,14} Recently, other investigators^{15,16} have suggested that modifying the ABI calculation method by using the lowest ankle pressure for each leg, divided by the highest brachial pressure, would improve sensitivity.^{15,16} This modified method for calculating an ABI leads to higher prevalence estimates, although it may degrade the specificity of the test.¹²

Our aim was to determine the prevalence of an abnormal ABI (<0.90) along with independent predictors, in an asymptomatic sample of 1017 older adults, 60 to 69 years old, enrolled in the ADVANCE study, using both standard and modified methods for calculating ABI.

Methods

Study design

This is a cross-sectional study design examining baseline data (collected between December 2001 and January 2004) among the healthy older controls enrolled in ADVANCE.

Subjects

A total of 1000 older men and women were targeted for enrollment in the study. Male and female members of Kaiser Permanente of Northern California, 60 to 69 years old (as of 01/06/2001), were identified in the health plan's electronic databases as potentially eligible participants, after excluding those with a major chronic disease or living >50 miles from the research clinic. Details of the recruitment plan have been previously reported.^{17,18} After screening and confirming eligibility, a total of 1023 older controls enrolled in the study. Complete data are available for 1017 subjects.

Approval to conduct the study was obtained from the institutional review boards at Stanford University Medical School and the Kaiser Foundation Research Institute. The investigation was carried out according to the principles outlined in the Declaration of Helsinki, including written informed consent from all subjects.

Data collection procedures

A comprehensive, self-administered health survey was mailed to subjects for completion prior to their baseline clinic visit. Survey items included age, gender, marital status, educational level, employment status, household income, birthplace, race/ethnicity, and self-reported medical history. Subjects' self-reported medical history included previous myocardial infarction, peripheral artery disease, stroke, hypertension, high cholesterol, diabetes mellitus, smoking status, alcohol consumption, major medical conditions, surgical procedures, major depression, and cancer. Subjects were also asked to bring all current medications for review at the baseline visit, and these were recorded by study staff.

Selected clinical measures were obtained at the clinic visit using standard methods and included blood pressure, height, weight and waist circumference, electrocardiogram, heart rate variability, coronary artery calcium score (CAC), and ABI. In addition, fasting blood

samples were drawn to obtain DNA for genetic studies and plasma for determination of lipid and lipoprotein levels, glucose, insulin, and C-reactive protein. Plasma and serum were also stored for future studies. Subjects found to have abnormal CVD risk factors, for example, ABI <0.90, were referred back to their primary health care provider for follow-up and treatment. Data were collected between December 2001 and January 2004.¹⁷

Measures

Ankle brachial index—Ankle brachial index was performed after subjects rested for at least 10 minutes in a supine position. Systolic blood pressure was measured using a handheld Doppler (Nicolet Vascular Elite 100; Madison, WI) with a 5-Mhz probe using transducer gel, in both right and left brachial, dorsalis pedis and posterior tibial arteries, unless contraindicated. The arm/ankle ratios were calculated using the standard definition, that is, highest ankle pressure for each leg, divided by the highest brachial pressure.^{13,14} In addition, the arm/ankle ratios were calculated using a modified definition, that is, lowest ankle pressure for each leg, divided by the highest brachial pressure.¹⁵ For both definitions, we used the leg with the lowest ABI for analysis.^{13,14}

Data analysis

All forms were reviewed for accuracy and completeness at the time of the clinic visit. Variable frequency distributions were used to check for extreme values. Descriptive statistics were calculated for all variables. Frequency distributions were calculated and included subject characteristics by ABI score as follows: ABI <0.90, ABI = 0.90–1.39, or ABI ≥ 1.40.^{19,20} Prevalence of PAD was determined using ABI <0.90 as the indicator. In addition, stepwise logistic regression was used to examine independent predictors of ABI <0.90. Finally, signal detection analysis was used to determine, through recursive partitioning, an algorithm that characterizes distinct subgroups of subjects that are mutually exclusive and maximally discriminated from each other with respect to a specific dichotomous outcome, that is, ABI <0.90.^{21–23} Signal detection allows for full use of all data available for each variable being evaluated. Data were analyzed using SAS (Version 9.1, SAS Institute Inc, Cary, NC).

The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the manuscript and its final contents. All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Results

Subjects were on average 66 years old. Most subjects were married, retired, and white, and 23% had graduated from college (Table I). Despite being selected as a healthy cohort, the subjects had a reasonably high prevalence of hypertension, dyslipidemia, physical inactivity, diabetes, and obesity. Compared with women, men were more likely to be married, have diabetes, a triglyceride/high-density lipoprotein (HDL) ratio ≥ 3, be more physically active, have a CAC score >10, and a FRS >20% ($P < .01$) (Table I).

Ankle brachial index prevalence

The prevalence of ABI <0.90 in our study was 2% when using the standard definition and 5% when using the modified definition for ABI calculation. There was no statistically significant difference in ABI prevalence by gender (Table I). Compared to subjects with a normal ABI (>0.90 – 1.39), subjects with an ABI <0.90 were more likely to currently smoke, be physically inactive, have a CAC score >10 , and a FRS $>20\%$ ($P = .02$), independent of method used for calculating ABI (Tables II and III). Almost 5% of subjects reported a history of lower extremity circulation problems, a single self-reported medical history item on the study questionnaire. As this single item may or may not represent claudication symptoms associated with PAD, we elected to eliminate these subjects ($n = 45$) from further analysis.

Ankle brachial index predictors

To see if we could derive a useful guide to aid practitioners in selecting patients for ABI screening, we examined several demographic and clinical variables as independent predictors of ABI <0.90 , including gender, current smoker, ever-smoker, waist circumference, body mass index (BMI) >30 , physical inactivity, diabetes, hypertension, and dyslipidemia. Significant independent predictors of ABI <0.90 when using the standard definition included currently smoking, physical inactivity, and BMI >30 (all $P = .03$). When using the modified definition, these included currently smoking, physical inactivity, and hypertension (all $P = .04$) (Table IV).

Another approach to guide patient selection for screening tests is to use recursive partitioning to derive a clinical decision tool. Recursive partitioning produces a series of dichotomies (yes/no questions) to guide clinical decision-making. This produced only one useful dichotomy, current smoking status ($P = .02$). In our study, the prevalence of ABI <0.90 was 1.5% for nonsmokers, while it was 6.6% for current smokers. Diabetes was not an independent predictor of ABI <0.90 in this study. This may be due to the fact that the prevalence of ABI <0.90 was very low (standard definition = 10/171, modified definition = 13/183) among the diabetics in our study.

Discussion

Peripheral arterial disease is often referred to as an under-diagnosed and under-treated public health problem. Patients with PAD have a significantly increased risk for serious CVD events, and risk factor management in PAD patients would likely reduce this risk. Therefore, routine screening for PAD using ABI has been advocated for all persons ≥ 50 years old with history of smoking or diabetes, and among all adults with lower extremity circulation problems indicative of claudication symptoms.²⁴ However, the prevalence of abnormal ABI in clinic-based studies may not indicate the performance of this test in less selected populations.^{25,26} For example, Wyman et al²⁵ used ABI to screen 493 subjects (mean age = 55 years) for subclinical atherosclerosis. Although subjects in this study had at least two CVD risk factors and a high prevalence of non-occlusive carotid plaque (56%), only one subject had an ABI <0.90 .

Screening tests done in epidemiological studies typically involve low-risk populations, requiring large samples with prolonged follow-up, to assess the impact of screening on disease-related outcomes or events.^{5,6} In our study (n = 1,017) of healthy older adults (mean age = 66 years), a total of 22 (2.2%) subjects had an ABI <0.90 when using the standard method for calculating the ABI. When using a modified definition for calculating the ABI, the prevalence was 5.5% (n = 52), an absolute increase of 2.9%. However, these estimates are below population estimates for community-dwelling adults 60 years and older,^{11,27–30} regardless of the definition used.

Presumably the lower estimated prevalence of ABI <0.90 in our study, compared to other reports, was due to our selection of a healthy cohort. We therefore compared the prevalence rates for smoking and diabetes in our sample to adults in California, as these are considered the two major risk factors for PAD for persons 50 to 69 years old.³¹ In 2004, current smoking among adults 18 years was 14.8%, and the prevalence of diabetes was 10–19.8% among adults 45 to 74 years old.^{32,33} In our study, 18% of subjects had a medical history of diabetes, were taking insulin or an oral hypoglycemic, or had a fasting blood glucose 126 mg/dL; these figures are comparable to the prevalence estimates among similar aged adults in California. However, only 7.5% of subjects were current smokers, which is only half of the reported smoking prevalence among adults in California and may, in part, explain the lower prevalence of ABI <0.90 in our study. However, age-specific smoking prevalence estimates are not available in California; therefore, smoking prevalence among adults 60 to 69 years old may be lower than the reported estimate for adults 18 years.

Recently, a large multisite study used a targeted screening strategy²⁶ among patients in primary care settings (n = 717) to identify persons with asymptomatic PAD (ABI <0.90). Persons 70 years old without known CVD, and those 50 to 69 years old with at least one CVD risk factor associated with PAD, that is, diabetes, smoking, hypertension, and/or dyslipidemia, were enrolled. Prevalence of ABI <0.90 among persons 70 years old was 12.5%, while among those 50 to 69 years old prevalence was only 2.5%, similar to our study. Approximately 72% of the subjects in this study with an ABI <0.90 reported a history of smoking.

It is well established that persons at higher risk for developing PAD include those with known CVD and diabetes.¹ Therefore, to improve targeted screening efforts for identifying PAD, Campbell et al.⁹ conducted a study in three high-risk groups, that is, smokers and those with either hypertension or dyslipidemia, from one large general practice in Scotland. Subjects (n = 343) were on average 70 years old. A total of 24 undiagnosed persons (6.9%) had an ABI <0.90, with 76% of these persons reporting a history of smoking.⁹

In another study, Eason et al.³⁴ used a cross-sectional study design in an ethnically diverse population (n = 403) drawn from four primary care clinics to screen for PAD (ABI <0.90). The average age was 64 years and the prevalence of asymptomatic PAD was approximately 6% (n = 25). After controlling for age and gender, the rate of asymptomatic PAD was higher in those with diabetes mellitus (3.8 times), and in those who smoked at least 1 pack of cigarettes/day (2.5 times). Our findings and the above cited studies all support the targeted ABI screening recommendations made by Beckman et al.,³¹ in particular, among

asymptomatic adults with a history of smoking, and represent a more efficient screening process compared to widespread or routine screening for PAD.

Since our study included a large number of variables, we attempted to discover other factors that might help refine ABI screening criteria and improve case-finding efficiency. We used a recursive partitioning method that is particularly suited to such, and which handles interactions quite well. However, only current smoking status was significant, so we were unsuccessful in this effort.

Study limitations

This large epidemiological study precluded us from doing angiography of lower extremities to confirm extremity occlusion in subjects with an ABI <0.90 . In addition, we were unable to follow up subjects with an ABI >1.40 to confirm or refute a diagnosis of PAD. Our prevalence estimates were based on a recruited sample of insured adults in Northern California and may not be fully generalizable to other populations and clinical settings. We also do not have sufficient follow-up events to examine the association between abnormal ABI and incidence of clinical cardiovascular events, in this population.

Conclusion

ABI screening in generally healthy individuals 60 to 69 years old may result in lower prevalence rates of a positive result, than estimates derived from clinic-based studies. Targeted screening using Beckman's recommendations³¹ appears to be more reasonable and efficient for identifying those at high risk for PAD and CVD. Since all diabetics are considered to have a high CVD risk equivalent,³⁵ screening for ABI is unlikely to change their treatment. Thus, it may be most efficient to perform ABI screening only in persons 50 to 69 years old with a history of smoking (former or current), and who have no other reason to implement aggressive preventive measures. In addition, using the modified definition for calculating ABI to capture more asymptomatic adults with suspected PAD is likely more efficient than the standard definition because in other studies, it was equally predictive of future events.^{15,16} However, more evaluation of the appropriate role of ABI screening in unselected populations is needed before routine screening is accepted as a standard of care.

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References

1. Hirsch AT, Haskal ZJ, Hertzler NR, et al. ACC/AHA 2005 Practice Guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): a collaborative report from the American Association for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Peripheral Arterial Disease): endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation; National Heart, Lung, and Blood Institute; Society for Vascular Nursing;

- TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation. *Circulation*. 2006; 113:e463–654. [PubMed: 16549646]
2. Fowkes FG, Murray GD, Butcher I, et al. Ankle brachial index combined with Framingham Risk Score to predict cardiovascular events and mortality: a meta-analysis. *JAMA*. 2008; 300:197–208. [PubMed: 18612117]
 3. Using nontraditional risk factors in coronary heart disease risk assessment: U S. Preventive Services Task Force recommendation statement. *Ann Intern Med*. 2009; 151:474–82. [PubMed: 19805770]
 4. Greenland P, Lloyd-Jones D. Defining a rational approach to screening for cardiovascular risk in asymptomatic patients. *J Am Coll Cardiol*. 2008; 52:330–2. [PubMed: 18652939]
 5. Fields MM, Chevelen E. Screening for disease: making evidence-based choices. *Clin J Oncol Nurs*. 2006; 10:73–6. [PubMed: 16482730]
 6. Herman CR, Gill HK, Eng J, et al. Screening for preclinical disease: test and disease characteristics. *AJR Am J Roentgenol*. 2002; 179:825–31. [PubMed: 12239019]
 7. Guo X, Li J, Pang W, et al. Sensitivity and specificity of ankle-brachial index for detecting angiographic stenosis of peripheral arteries. *Circ J*. 2008; 72:605–10. [PubMed: 18362433]
 8. Mark DB, Shaw LJ, Lauer MS, et al. 34th Bethesda Conference: Task force #5—Is atherosclerosis imaging cost effective? *J Am Coll Cardiol*. 2003; 41:1906–17. [PubMed: 12798557]
 9. Campbell NC, McNiff C, Sheran J, et al. Targeted screening for peripheral arterial disease in general practice: a pilot study in a high risk group. *Br J Gen Pract*. 2007; 57:311–5. [PubMed: 17394735]
 10. Margolis J, Barron JJ, Grochulski WD. Health care resources and costs for treating peripheral artery disease in a managed care population: results from analysis of administrative claims data. *J Manag Care Pharm*. 2005; 11:727–34. [PubMed: 16300416]
 11. Hirsch AT, Criqui MH, Treat-Jacobson D, et al. Peripheral arterial disease detection, awareness, and treatment in primary care. *JAMA*. 2001; 286:1317–24. [PubMed: 11560536]
 12. Lange SF, Trampisch HJ, Pittrow D, et al. Profound influence of different methods for determination of the ankle brachial index on the prevalence estimate of peripheral arterial disease. *BMC Public Health*. 2007; 7:147. [PubMed: 18293542]
 13. Sacks D, Bakal CW, Beatty PT, et al. Position statement on the use of the ankle brachial index in the evaluation of patients with peripheral vascular disease. A consensus statement developed by the Standards Division of the Society of Interventional Radiology. *J Vasc Interv Radiol*. 2003; 14(9 Pt 2):S389. [PubMed: 14514853]
 14. Redberg RF, Vogel RA, Criqui MH, et al. 34th Bethesda Conference: Task Force #3—what is the spectrum of current and emerging techniques for the noninvasive measurement of atherosclerosis? *J Am Coll Cardiol*. 2003; 41:1886–98. [PubMed: 12798555]
 15. Espinola-Klein C, Rupprecht HJ, Bickel C, et al. Different calculations of ankle-brachial index and their impact on cardiovascular risk prediction. *Circulation*. 2008; 118:961–7. [PubMed: 18697822]
 16. Schroder F, Diehm N, Kareem S, et al. A modified calculation of ankle-brachial pressure index is far more sensitive in the detection of peripheral arterial disease. *J Vasc Surg*. 2006; 44:531–6. [PubMed: 16950430]
 17. Taylor-Piliae RE, Norton LC, Haskell WL, et al. Validation of a new brief physical activity survey among men and women aged 60–69 years. *Am J Epidemiol*. 2006; 164:598–606. [PubMed: 16840522]
 18. Fair JM, Kiazand A, Varady A, et al. Ethnic differences in coronary artery calcium in a healthy cohort aged 60 to 69 years. *Am J Cardiol*. 2007; 100:981–5. [PubMed: 17826382]
 19. Resnick HE, Lindsay RS, McDermott MM, et al. Relationship of high and low ankle brachial index to all-cause and cardiovascular disease mortality: the Strong Heart Study. *Circulation*. 2004; 109:733–9. [PubMed: 14970108]
 20. Allison MA, Hiatt WR, Hirsch AT, et al. A high ankle-brachial index is associated with increased cardiovascular disease morbidity and lower quality of life. *J Am Coll Cardiol*. 2008; 51:1292–8. [PubMed: 18371562]
 21. Kiernan M, King AC, Kraemer HC, et al. Characteristics of successful and unsuccessful dieters: an application of signal detection methodology. *Ann Behav Med*. 1998; 20:1–6. [PubMed: 9755345]

22. Kiernan M, Kraemer HC, Winkleby MA, et al. Do logistic regression and signal detection identify different subgroups at risk? Implications for the design of tailored interventions. *Psychol Methods*. 2001; 6:35–48. [PubMed: 11285811]
23. King AC, Kiernan M, Oman RF, et al. Can we identify who will adhere to long-term physical activity? Signal detection methodology as a potential aid to clinical decision making. *Health Psychol*. 1997; 16:380–9. [PubMed: 9237091]
24. Greenland P, Smith SC Jr, Grundy SM. Improving coronary heart disease risk assessment in asymptomatic people: role of traditional risk factors and noninvasive cardiovascular tests. *Circulation*. 2001; 104:1863–7. [PubMed: 11591627]
25. Wyman RA, Keevil JG, Busse KL, et al. Is the ankle-brachial index a useful screening test for subclinical atherosclerosis in asymptomatic, middle-aged adults? *WMJ*. 2006; 105:50–4. [PubMed: 17042421]
26. Doubeni CA, Yood RA, Emani S, et al. Identifying unrecognized peripheral arterial disease among asymptomatic patients in the primary care setting. *Angiology*. 2006; 57:171–80. [PubMed: 16518524]
27. Screening for peripheral arterial disease: recommendation statement. *Am Fam Physician*. 2006; 73:497–500. [PubMed: 16477898]
28. Cacoub P, Cambou JP, Kownator S, et al. Prevalence of peripheral arterial disease in high-risk patients using ankle-brachial index in general practice: a cross-sectional study. *Int J Clin Pract*. 2009; 63:63–70. [PubMed: 19125994]
29. Doobay AV, Anand SS. Sensitivity and specificity of the ankle-brachial index to predict future cardiovascular outcomes: a systematic review. *Arterioscler Thromb Vasc Biol*. 2005; 25:1463–9. [PubMed: 15879302]
30. Michos ED, Rice KM, Szklo M, et al. Factors associated with low levels of subclinical vascular disease in older adults: multi-ethnic study of atherosclerosis. *Prev Cardiol*. 2009; 12:72–9. [PubMed: 19476580]
31. Beckman JA, Jaff MR, Creager MA. The United States preventive services task force recommendation statement on screening for peripheral arterial disease: more harm than benefit? *Circulation*. 2006; 114:861–6. [PubMed: 16923770]
32. Diabetes Data and Trends: National Database Surveillance System. Centers for Disease Control and Prevention; 2010. Percentage of adults with diagnosed diabetes by age, 1994–2008-California. Available at: <http://www.cdc.gov/diabetes/statistics/index.htm>
33. State-specific prevalence of cigarette smoking and quitting among adults—United States, 2004. *Morbidity & Mortality Weekly Report*. 2005; 54:1124–7. [PubMed: 16280970]
34. Eason SL, Petersen NJ, Suarez-Almazor M, et al. Diabetes mellitus, smoking, and the risk for asymptomatic peripheral arterial disease: whom should we screen? *J Am Board Fam Pract*. 2005; 18:355–61. [PubMed: 16148245]
35. Lloyd-Jones D, Adams R, Carnethon M, et al. Heart disease and stroke statistics—2009 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation*. 2009; 119:e21–181. [PubMed: 19075105]

Table I

ADVANCE older controls with ABI score, baseline characteristics, n = 1017

	Total, n = 1017	Women, n = 381	Men, n = 636	P-value, gender differences
Age, mean years (SD)	65.8(2.8)	65.8(2.8)	65.8(2.9)	.69
Employed part or full-time, %	39.3	36.5	41.3	.16
Married, %	77.3	65.6	84.3	<.01
College graduate, %	23.3	21.1	24.7	.19
Race/ethnicity				
White/European, %	67.5	66.9	67.8	.78
Black/African-American, %	8.2	6.8	9.0	.23
Hispanic, %	6.0	6.6	5.7	.59
Asian/Pacific Islander, %	7.8	7.3	8.0	.80
Mixed, Hispanic, %	3.0	2.6	3.3	.58
Mixed, Non-Hispanic, %	7.6	9.7	6.3	.05
Cardiovascular disease risk Factors				
Current smoker, %	7.5	8.1	7.1	.53
Diabetes*, %	18.0	11.0	22.2	<.01
Metabolic Syndrome, (n = 989)				
Metabolic syndrome with diabetes, %	10.8	7.7	12.7	.01
Metabolic syndrome without diabetes, %	18.9	19.1	18.8	.93
Obesity				
BMI 30 kg/m ² , %	32.0	31.0	32.4	.68
Waist 88cm (women only), %	—	38.8	—	—
Waist 102cm (men only), %	—	—	36.9	—
Hypertension [†] , %	66.6	63.3	68.6	.09
Dyslipidemia [‡]				
LDL >160 mg/dL, % (n = 992)	11.8	12.4	11.4	.68
Triglycerides 150 mg/dL, %, n = 1006	32.3	29.2	34.1	.12
Triglyceride/HDL Ratio 3, %	36.7	26.3	42.8	<.01
Physical inactivity				
SBAS <moderate, %, n = 1015	38.7	38.9	38.6	.94
PAR kcal/kg per day 33, %, n = 1009	36.0	45.6	30.2	<.01
Coronary calcium score >10, %, n = 1008	62.4	40.9	75.4	<.01
Framingham Risk Score >20%, %, n = 1006	20.1	3.2	30.0	<.01
ABI score ¹³ <0.90, % (standard definition) (highest DP or PT/highest SBP)	2.2	1.0	2.8	.07
ABI score ¹⁵ <0.90, % (modified definition) (lowest DP or PT/highest SBP)	5.1	5.0	5.2	1.00
Hx lower extremity circulation problems, %	4.5	3.8	4.9	.43

SBAS, Stanford Brief Activity Survey; PAR, 7-day physical activity recall; DP, dorsalis pedis; PT, posterior tibial; SBP, systolic blood pressure; Hx, history. Bold type indicates *P*-value < 0.05.

* Medical history of diabetes, taking insulin or oral hypoglycemic, or fasting blood glucose > 126 mg/dL.

[†]SBP >140 mm Hg, diastolic blood pressure >90 mm Hg, medical history of hypertension or taking anti-hypertensives.

[‡]Includes medical history or medications.

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Table IISubject characteristics by ABI score using *standard definition* for ABI calculation, n = 1017

ABI score frequency, n	ABI score			χ^2 [df = 2]	P
	<0.90	0.90–1.39	1.40		
	22	984	11		
% within ABI Score Category					
Cardiovascular disease risk factors					
Current Smoker	23	7	18	9.53	<.01
Obesity					
BMI 30 kg/m ²	55	32	18	6.22	.04
Waist 88cm (women only), n = 381	50	39	0	1.48	.47
Waist 102cm (men only), n = 635	56	37	22	3.56	.17
Diabetes*	41	17	27	8.72	.01
Hypertension†	82	66	55	3.03	.22
Dyslipidemia‡					
LDL >160 mg/dL	68	44	36	5.43	.07
Triglycerides 150 mg/dL	41	32	18	2.07	.35
Triglyceride/HDL Ratio 3	86	81	91	1.60	.45
Physical Inactivity§	73	38	18	12.80	<.01
Coronary Calcium Score >10	86	51	91	9.50	<.01
Framingham Risk Score >20%	50	19	18	13.96	<.01

Bold type indicates *P*-value 0.05.

* Medical history of diabetes, taking insulin or oral hypoglycemics, or fasting blood glucose 126 mg/dL.

† SBP >140 mm Hg, diastolic blood pressure >90 mm Hg, medical history of hypertension or taking anti-hypertensives.

‡ Includes medical history or medications.

§ Not meeting national recommendations.

Table IIISubject Characteristics by Ankle-Brachial Index Score using *Modified Definition* for ABI calculation, n = 1017

	Ankle-Brachial Index Score			χ^2 [df = 1]	P-value
	% within ABI Score Category, n = 1015				
	<0.90	0.90–1.39	1.40		
	52	963	2		
ABI Score Frequency, n					
% within ABI Score Category, n = 1015					
Cardiovascular disease risk factors					
Current Smoker	15	7	—	5.12	.02
Obesity					
Body Mass Index 30 kg/m ²	42	31	—	2.78	.09
Waist 88cm (women only), n = 381	37	39	—	0.03	.85
Waist 102cm (men only), n = 633	49	36	—	1.98	.16
Diabetes*	25	18	—	1.86	.17
Hypertension†	85	66	—	8.00	<.01
Dyslipidemia‡					
LDL >160 mg/dL	56	44	—	3.00	.08
Triglycerides 150 mg/dL	31	32	—	0.07	.79
Triglyceride/HDL Ratio 3	88	82	—	1.10	.30
Physical Inactivity§	60	38	—	10.01	<.01
Coronary Calcium Score >10	77	62	—	4.98	.03
Framingham Risk Score >20%	33	19	—	5.13	.02

Bold type indicates P-value 0.05.

* Medical history of diabetes, taking insulin or oral hypoglycemics, or fasting blood glucose 126 mg/dL.

† SBP >140 mm Hg, diastolic blood pressure >90 mm Hg, medical history of hypertension or taking anti-hypertensives.

‡ Includes medical history or medications.

§ Not meeting national recommendations.

Table IVPredictors for Ankle-Brachial Index <0.90 using Stepwise Logistic Regression^{*}, n = 940[†]

Variable [‡]	Standard definition for ABI <0.90		Modified definition for ABI > 0.90	
	χ^2 [df = 1]	Odds ratio (95% CI)	χ^2 [df = 1]	Odds Ratio (95% CI)
Current smoker	11.08	5.35 (1.77–16.22)	7.16	2.72 (1.20–6.17)
Physical inactivity	4.29	2.98 (1.02–8.73)	4.30	1.92 (1.03–3.58)
BMI>30	7.14	2.97 (1.08–8.17)	—	—
Hypertension	—	—	5.10	2.31 (1.05–5.06)

* Variables entered into model: current smoker, ever smoker, BMI >30, waist < 88cm (women only), waist < 102 cm (men only), diabetes (medical history of diabetes, taking insulin or oral hypoglycemics, or fasting blood glucose < 126 mg/dL), hypertension (SBP >140 mm Hg, DBP>90 mm Hg, medical history of hypertension or taking anti-hypertensives), Physical inactivity, LDL >160 mg/dL or taking cholesterol lowering medications, triglycerides < 150 mg/dL, and triglyceride/HDL Ratio < 3.

[†] Subjects with history of lower extremity circulation problems removed from analysis (n = 45).

[‡] All variables listed have χ^2 P-values < .04.