Lower ankle/brachial index, as calculated by averaging the dorsalis pedis and posterior tibial arterial pressures, and association with leg functioning in peripheral arterial disease

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Objective: **We compared three commonly used methods of ankle/brachial index (ABI) calculation to determine their relative association with objective measures of leg functioning in peripheral arterial disease.**

Method: **The study design was cross-sectional; the setting was an academic medical center. The participants were 244 men and women, aged 55 years and older, with and without peripheral arterial disease, from a noninvasive vascular laboratory and a general medicine practice. The main outcome measures were walking velocity and endurance, measured with the 4-m walk and the 6-minute walk, respectively. Three methods of ABI calculation were assessed: using the highest arterial pressure within each leg (method #1), using the lowest pressure in each leg (method #2), and averaging the dorsalis pedis and posterior tibial pressures within each leg (method #3). For each method, we established the prevalence of peripheral arterial disease. We then used regression analyses to identify the ABI calculation method most closely associated with leg functioning. The ABI with the greatest statistical significance and largest regression coefficient was considered most closely associated with leg functioning.**

Results: **Peripheral arterial disease prevalence ranged from 47% when method #1 was used to 59% when method #2 was used. When the right and left legs were compared, the leg with the lower ABI, as identified through use of method #3, was most associated with leg functioning. Within the leg with the lower ABI, method #3 was more closely associated with 6-minute walk distance (regression coefficient = 811.5 feet per 1 unit ABI; $P < .001$) and 4-m walking velocity (regression coefficient = 0.353 m/s per 1 unit ABI; $P < .001$) than method #1 or method #2.**

Conclusion: **The lower ABI, determined by averaging the dorsalis pedis and posterior tibial arterial pressures in each leg, is most predictive of walking endurance and walking velocity in peripheral arterial disease. (J Vasc Surg 2000;32:1164-71.)**

The ankle/brachial index (ABI) is regarded as a reliable, noninvasive measure of the presence and severity of lower extremity peripheral arterial disease (PAD).[1] The ABI independently predicts total mortality, cardiovascular mortality, and cardiovascular morbidity.[2-5] In cross-sectional analyses, the ABI is associated independently with lower extremity functioning.[6]

Systolic pressure measurements in the dorsalis pedis and posterior tibial arteries in each leg are used

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Competition of interest: nil.

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to determine the ABI, yielding up to 4 ABIs per individual. However, only one ABI is typically used to diagnose PAD, predict risk of future cardiovascular events, or assess lower extremity functioning.

In epidemiologic studies, methods used to calculate the ABI vary. In some reports, the highest arterial pressure in each leg is used to calculate the ABI.[4,7] In others, the lowest arterial pressure in each leg is used to calculate the ABI.[6,8] Alternatively, the dorsalis pedis and posterior tibial arterial pressures within the leg are averaged,[9] or the posterior tibial arterial pressures in the right and left legs are averaged.[3,10] To our knowledge, no prior studies have identified the method of ABI calculation most predictive of leg functioning, cardiovascular outcomes, or progression of lower extremity arterial ischemia in PAD. Published guidelines on PAD diagnosis also do not provide recommendations on how the four lower extremity arterial pressures should be used to calculate the ABI in clinical settings or epidemiologic studies.[11,12]

We conducted a systematic study of ABI values, calculated from the left and right legs among men and women aged 55 years and older in an academic medical center, to determine how PAD prevalence varied with the method of ABI calculation and to identify the method of ABI calculation best correlated with lower extremity functioning. We defined three methods of ABI calculation based on the methods most commonly used in previous epidemiologic studies.[4-9] In method #1, the highest arterial pressure in the leg (dorsalis pedis or posterior tibial arterial pressure) was used as the numerator to calculate the ABI. In method #2, the lowest arterial pressure in the leg was used for ABI calculation. In method #3, the average of the dorsalis pedis and posterior tibial arterial pressures within the leg was used to calculate the ABI. We established the prevalence of PAD for each method of ABI calculation. We then used a two-step process to identify the ABI most closely associated with lower extremity functioning. For each analysis in which two methods of ABI calculation were compared, the ABI with greater statistical significance and higher regression coefficient in regression models was considered "most closely associated with" or "most predictive of" leg functioning. First, we determined whether the leg with the higher ABI or the leg with the lower ABI was most closely associated with leg functioning. On the basis of these results, we then compared the three methods of ABI calculation within one leg for their relative associations with objectively measured leg functioning.

METHODS

Participant identification

The study protocol was approved by the Institutional Review Board of Northwestern University Medical School. All participants gave informed consent. Consecutive patients aged 55 years and older diagnosed with PAD at the study institution's noninvasive vascular laboratory (VL) between January 1, 1996, and November 1, 1996, were identified and enrolled between January 1, 1996, and July 31, 1997. In the VL, both waveforms and ABI were used to diagnose PAD. Patients aged 55 years and older with appointments in a large general internal medicine practice (GIM) at the study institution were identified and randomly selected through use of a computer program between January 1, 1996, and August 31, 1998. Each identified individual was contacted and invited to return to the medical center for a study visit. At the study visits, PAD participants were those men and women with ABIs less than 0.90. Non-PAD participants were those men and women with ABIs of 0.90 to 1.50.

Exclusion criteria

Patients with a Mini-Mental Status Examination score of less than 18 of 30 were excluded (GIM, 6; VL, 3). Nursing home residents (GIM, 3; VL, 6), wheelchair-bound patients (GIM, 5; VL, 12), and patients with foot or leg amputations (GIM, 3; VL, 23) were excluded because these individuals have uniquely impaired functioning. Patients with lower extremity ulcers were excluded because of concerns about placing blood pressure cuffs over open ulcers for ABI measurement (GIM, 0; VL, 4). Non–English-speaking patients were excluded because study investigators were not fluent in non-English languages (GIM, 7; VL, 10). ABI values of 1.50 or higher were excluded from analyses, and participants with one or more ABI values of 0 were excluded. Participants with PAD identified in the VL who were found to have normal ABIs in all four lower extremity arteries at the study visit were also excluded (n = 41).

Ankle/brachial index measurement

The participant rested supine for 5 minutes before ABI measurement. Appropriately sized blood pressure cuffs were placed over each brachial artery and above each malleolus. The cuff was rapidly inflated to 20 mm Hg above the audible systolic pressure in each arm and deflated in 2-mm/s increments. Through use of a hand-held 5-MHz Doppler scanning probe (Nicolet Vascular Pocket Dop II, Golden, Colo), systolic pressure was measured once in each of the following: right brachial artery, right dorsalis pedis and posterior tibial arteries, left dorsalis pedis and posterior tibial arteries, and left brachial artery. The systolic pressure as recorded was the pressure at which the systolic pressure was first audible. The order of measurement was the same for all participants.

We collected quality control data for ABI measurement on a subset of 20 participants (12 with PAD) by having the ABIs measured by two independent observers (including M. M. M.). For the two observers, the mean ABIs for these 20 participants were 0.79 and 0.76. The Pearson correlation coefficient was 0.93.

Ankle/brachial index calculation

The ABI was calculated through use of each of the three methods, as described. The ABI was calculated by dividing the lower extremity arterial pressure (defined as described for each method) by the brachial artery pressure. The brachial artery pressure was the average of the left and right brachial artery pressures. If brachial artery pressures differed by 10 mm Hg or more, subclavian stenosis in the arm with lower pressure was suspected and the highest brachial artery pressure was used in the ABI calculation.[13]

Leg functioning measurements

Leg functioning was measured in terms of the 6-minute walk distance and the 4-m walking velocity, the latter performed at the usual and fastest paces.

Six-minute walk performance. Among PAD patients with intermittent claudication, distance achieved on the 6-minute walk is significantly correlated with physical activity levels, ABI level, and performance on a treadmill graded exercise test.[6,14,15] In 64 intermittent claudication patients who performed the 6-minute walk twice during 1 week, the coefficient of variation for the two tests was 10.4%, indicating a very reliable test.[14] In the 6-minute walk, participants walk up and down a 100-ft hallway for 6 minutes.[16] Before they begin the walk, participants are instructed to complete as many laps as possible. Participants are told that they may rest during the 6 minutes, but they are encouraged to resume walking if they are able. A research assistant walks slightly behind the participant, calling out each completed minute. The distance walked at the end of 6 minutes is recorded.[16]

Four-meter walking velocity. Walking velocity was measured with a 4-m walk that was performed at the usual and fastest paces. Walking velocity predicts future mobility loss and disability in Activities of Daily Living among community-dwelling men and women aged 70 years and older.[17] In addition, slower walking velocity is associated with being homebound.[18]

A 4-m distance was marked out in a hallway. Each participant stood at the starting line with feet together. Timing began with the participant's first movement after a "Go" command; timing stopped when the first foot had completely crossed the finish line.[17] The 4-m walk was performed at the "usual" pace and at the "fastest" pace. Each of these walks was performed twice, and the fastest walk in each set (usual pace and fastest pace) was used in analyses.[17]

Statistical analyses

The prevalence of PAD was determined for each ABI calculation method. SPSS version 10.0 statistical software (SPSS Inc, Chicago, Ill) was used for all analyses. χ^2 Tests of association and Student t tests were used to compare characteristics between PAD and non-PAD participants for categoric and continuous variables, respectively. Spearman correlation coefficients were used to determine correlations between ABIs calculated from the dorsalis pedis and posterior tibial arteries in each leg.

We next determined whether the ABI calculated from the leg with higher arterial pressures or the ABI calculated from the leg with lower arterial pressures was most predictive of leg functioning. Multiple linear regression analyses were performed to identify which ABI (higher vs lower) was most closely associated with leg functioning, adjustments being made for age and sex. This comparison was made three times, once for each of the three methods of ABI calculation. Age and sex were adjusted because both are associated independently with lower extremity functioning[6] and because the PAD group was slightly older and included a higher proportion of males than the non-PAD group. The regression coefficients relate differences in performance on the leg functioning tests per a 1-unit change in ABI value. Thus, higher regression coefficients indicated a greater linear association between performance on the functional measure and ABI.

Linear regression analyses were first performed to assess individual associations between (1) the leg with the lower ABI (independent variable) and the 6-minute and 4-m walks, respectively (dependent variables), and (2) the leg with the higher ABI (independent variable) and the 6-minute and 4-m walks, respectively (dependent variables). Analyses relating each ABI to lower extremity functioning were labeled "model A." Next, regression analyses

Table I. Characteristics of men and women with and without PAD, according to method of ABI calculation (n = 244)

	Method #1		*Method #2*		*Method #3*	
	Non-PAD (n = 129)	*PAD (n = 115)*	*Non-PAD (n = 101)*	*PAD (n = 143)*	*Non-PAD (n = 117)*	*PAD (n = 127)*
PAD prevalence (%)		47		59		52
Age (y)	69 ± 8*	72 ± 9*	68 ± 7*	71 ± 9*	68 ± 7*	72 ± 10*
Mean ABI	1.11 ± 0.10*	0.66 ± 0.14*	1.06 ± 0.08*	0.60 ± 0.18*	1.08 ± 0.09*	0.63 ± 0.15*
Male (%)	43	53	43	52	40	55
African American (%)	22	19	22	20	24	17
Diabetes mellitus (%)	18	27	15*	26*	26	25

*$P < .05$ for comparison between PAD and non-PAD participants. Method #1: ABI is calculated from highest pressure in leg. Method #2: ABI is calculated from lowest pressure in the leg. Method #3: ABI is calculated by averaging dorsalis pedis and posterior tibial pressures.

were repeated to include both the lower and higher ABIs as independent variables in one model; these analyses were labeled "model B." The purpose of model A was to assess the relationship between each ABI calculation method and the dependent variable (functioning). The purpose of model B was to relate the independent variables (eg, lower leg ABI) with the dependent variable (functioning) after removing the effect of the other independent variables (eg, lower leg ABI). Comparisons were made between *P* values and regression coefficients for the lower and higher ABIs in model A vs model B. In going from model A to model B, when the regression coefficient for one ABI (eg, lower leg ABI) retained statistical significance while the regression coefficient for the other ABI (eg, higher leg ABI) lost statistical significance, the ABI variable that retained statistical significance was considered more closely associated with the dependent variable than the ABI variable that declined in significance. On the basis of these results, subsequent analyses were performed to determine which of the three ABI calculation methods within a single leg was most closely associated with lower extremity functioning. The statistical methods used were similar to those previously described.

RESULTS

Of the 528 limbs for the 264 eligible study participants, eight arteries from eight participants had ABI values greater than 1.50 and were excluded from analyses. An additional six participants had one or more ABI values of 0, and six had missing data for an ABI. These 12 participants were also excluded from analyses. Among the remaining 244 participants, 119 were identified from the noninvasive VL and 125 were identified from GIM. In addition, 117 (48%) of the 244 participants were male. The prevalence of diabetes mellitus was 25% among PAD participants and 17% among non-PAD participants. Of the 119 participants from the noninvasive VL, each of 23 (19%) had at least one ABI less than 0.40 and each of 44 (29%) had at least one ABI less than 0.50.

With PAD defined as an ABI less than 0.90, the number of patients with PAD varied from a minimum of 115 (47%) for method #1 (the higher arterial pressure in each leg being used to define the ABI) to a maximum of 143 (59%) for method #2 (the lower arterial pressure in each leg being used to define the ABI). Table I compares characteristics between PAD and non-PAD participants according to each method of ABI calculation.

In regression analyses comparing legs with higher ABIs and legs with lower ABIs, lower leg ABIs were consistently more closely associated with walking velocity and 6-minute walk performance than higher leg ABIs (Table II). This relationship was observed regardless of the ABI calculation method used to define the higher and lower ABIs. In individual regression analyses, higher and lower ABIs were frequently both associated significantly with leg functioning (model A). However, in model B, results showed a substantial decline in the regression coefficient and loss of statistical significance for the leg with the higher ABI, whereas the regression coefficient for the leg with the lower ABI increased and its statistical significance remained high. These findings indicated that the leg with the lower ABI was more closely associated with leg functioning and that the leg with the higher ABI did not contribute additionally to this relationship. Regression coefficients for the leg with the lower ABI were almost always higher for method #3 than for method #1 or method #2, indicating that the lower leg ABI determined through use of method #3 was more strongly related to the functional measures than the lower leg ABI determined through use of method #1 or

Table II. Between-leg comparisons: regression analyses comparing associations of lower leg versus higher leg ABIs with measures of lower extremity functioning among men and women aged 55 years and older (n = 244)

	Method #1		*Method #2*		*Method #3*	
	Lower leg	*Higher leg*	*Lower leg*	*Higher leg*	*Lower leg*	*Higher leg*
All study participants (n = 244)						
Six-min walk						
Feet/1 unit ABI (model A)	805.4†	710.4†	778.1†	754.3†	811.5†	768.9†
Feet/1 unit ABI (model B)	961.7†	–230.6	800.3†	–35.7	936.9†	–190.6
Four-m walk: usual pace						
Meters per second/1 unit ABI (model A)	0.348†	0.295†	0.3337†	0.333†	0.353†	0.328†
Meters per second/1 unit ABI (model B)	0.451†	–0.152	0.331†	0.009	0.429†	–0.115
Four-m walk: fast pace						
Meters per second/1 unit ABI (model A)	0.432†	0.332*	0.455†	0.348*	0.462†	0.358†
Meters per second/1 unit ABI (model B)	0.623†	–0.283	0.608†	–0.244	0.705†	–0.367
PAD participants only						
Six-min walk						
Feet/1 unit ABI (model A)	659.0*	102.4	755.0†	349.1	832.4†	251.1
Feet/1 unit ABI (model B)	754.1†	–172.7	760.0†	-9.37	930.8†	–169.5
Four-m walk: usual pace						
Meters per second/1 unit ABI (model A)	0.353	–0.02	0.239	0.123	0.464*	0.109
Meters per second/1 unit ABI (model B)	0.457*	–0.186	0.234	0.010	0.544*	–0.140
Four-m walk: fast pace						
Meters per second/1 unit ABI (model A)	0.572	–0.04	0.413	0.009	0.703†	0.027
Meters per second/1 unit ABI (model B)	0.735*	–0.297	0.538*	–0.246	0.923†	–0.385

Number of PAD participants varied depending on method used to define ABI (see Table I).
Method #1: ABI is calculated from highest arterial pressure in each leg. Method #2: ABI is calculated from lowest pressure in each leg. Method #3: ABI is calculated by averaging dorsalis pedis and posterior tibial pressures.
Lower leg: leg with lower ABI. Higher leg: leg with higher ABI. Model A: regression coefficients for lower leg and higher leg ABIs when each is assessed individually in regression models. Model B: regression coefficients when lower and higher ABIs are combined in 1 regression model. Results are age- and sex-adjusted and are shown per 1 unit ABI.
*$P < .01$
†$P < .001$.

method #2 (Table II). On the basis of these results, subsequent analyses were performed within the leg with the lower ABI, method #3 being used to define the leg with the lower ABI.

Among all participants, Spearman ρ correlation coefficients between ABIs calculated from the dorsalis pedis and posterior tibial arteries were 0.880 ($P < .001$) for the left leg and 0.846 ($P < .001$) for the right leg. Correlation coefficients between ABIs calculated from the dorsalis pedis and posterior tibial arteries were lower among PAD participants. When method #3 was used to define PAD, correlation coefficients between the dorsalis pedis and posterior tibial arteries were 0.755 ($P < .001$) for the left leg and 0.789 ($P < .001$) for the right leg.

Table III compares ABIs calculated through use of method #1 with ABIs calculated through use of method #3. In model A, ABIs calculated through use of method #1 and method #3, respectively, were associated independently with walking endurance and walking velocity. However, in model B, the strength of the regression coefficients was largely maintained for the ABIs calculated through use of method #3, whereas those for the ABI calculated through use of method #1 were not maintained. These findings indicate that the ABI calculated through use of method #3 was more closely associated with lower extremity functioning than the ABI calculated through use of method #1. As shown in Table IV, the ABI calculated through use of method #3 is more predictive of functioning than the ABI calculated through use of method #2. Our findings were consistent for each objective measure of functioning and were consistent when repeated among PAD participants only. Thus, the ABI calculated through use of method #3 was more closely associated with lower extremity functioning than either the ABI calculated through use of method #1 or the ABI calculated through use of method #2.

Two additional comparisons were made. First, comparison of the lower leg ABI as determined from method #3 with the average of all 4 lower extremity ABIs showed that the former method of ABI calculation was most predictive of leg functioning in all comparisons. Second, comparison of the leg with the lower ABI determined from method #3 against

Table III. Within-leg comparisons: comparison of average ABI (method #3) versus highest ABI (method #1) as measures of lower extremity functioning among men and women aged 55 years and older

	Method #1	*P value*	*Method #3*	P *value*
All study participants (n = 244)				
Six-min walk				
Feet/1 unit ABI (model A)	805.4	< .001	811.5	< .001
Feet/1 unit ABI (model B)	112.6	.817	701.5	.149
Four-m walk: usual pace				
Meters per second/1 unit ABI (model A)	0.348	< .001	0.353	< .001
Meters per second/1 unit ABI (model B)	0.032	.315	0.322	.309
Four-m walk: fastest pace				
Meters per second/1 unit ABI (model A)	0.432	< .001	0.462	< .001
Meters per second/1 unit ABI (model B)	–0.580	.193	1.031	.021
PAD patients only (n = 115)				
Six-min walk				
Feet/1 unit ABI (model A)	659.0	.005	832.4	< .001
Feet/1 unit ABI (model B)	–312.6	.642	1044.0	.126
Four-m walk: usual pace				
Meters per second/1 unit ABI (model A)	0.353	.016	0.464	< .001
Meters per second/1 unit ABI (model B)	0.086	.836	0.284	0.500
Four-m walk: fastest pace				
Meters per second/1 unit ABI (model A)	0.572	.1	0.703	< .001
Meters per second/1 unit ABI (model B)	–0.380	.537	1.020	.101

All analyses were performed within leg with lower ABI, defined by averaging dorsalis pedis and posterior tibial arterial pressures in each leg.

the ABI calculated by averaging the posterior tibial arterial pressures in the right and left legs showed that the former method was more predictive of functioning in all comparisons.

DISCUSSION

The ABI is an important clinical tool for noninvasive diagnosis of PAD, risk stratification for cardiovascular events, and assessment of lower extremity functioning in PAD. Screening high-risk patients in the clinical setting for PAD with the ABI has been recommended by the American Heart Association.[11,12] However, previous guidelines have not provided recommendations for the optimal method of ABI calculation in the clinical or research setting. Furthermore, studies demonstrating the prognostic implications of the ABI have not calculated ABI uniformly. Specifically, previous studies demonstrating the inverse association between ABI and mortality have used distinct methods of calculating the ABI. In McKenna et al's[4] study of 5-year mortality rates among 744 men and women identified from a noninvasive VL, the lower leg ABI was determined from the higher of the posterior tibial and dorsalis pedis arterial pressures in each leg (method #1). In a study by Vogt et al[9] of 1930 patients identified from a noninvasive VL and followed for 13 years for mortality after noninvasive lower extremity arterial testing, the ABI was calculated through use of the lower of the average dorsalis pedis and posterior tibial arterial pressures in each leg (method #3). In the Systolic Hypertension in the Elderly Program, the ABI was calculated by averaging the posterior tibial arterial pressures in the right and left legs.[5] Although these studies and others have consistently shown an independent inverse relationship between ABI and mortality, the optimal method of ABI calculation for predicting mortality and other outcomes in PAD has to our knowledge not been determined. Our study was designed to determine which of 3 regularly used methods of ABI calculation was most closely associated with lower extremity functioning.

Notably, the method of ABI calculation substantially influenced the prevalence of PAD in our cohort. PAD prevalence ranged from a minimum of 47% when method #1 was used to calculate ABI to a maximum of 59% when method #2 was used. This observed difference in PAD prevalence underscores the importance of identifying the method of ABI calculation with the greatest clinical significance for outcomes in PAD.

Results of our comparison of ABIs calculated from the right and left legs showed that the ABI of the leg with lower arterial pressures correlated better with leg functioning than the ABI calculated from the leg with higher arterial pressures. Although this finding was consistent regardless of which method of ABI calculation was used to define the higher and lower ABIs, regression coefficients and statistical sig-

Table IV. Within-leg comparisons: average ABI (method #3) vs lowest ABI (method #2) as measures of lower extremity functioning among men and women aged 55 years and older

	Method #2	*P value*	*Method #3*	P *value*
All study participants (n = 244)				
Six-min walk				
Feet/1 unit ABI (model A)	778.1	< .001	811.5	< .001
Feet/1 unit ABI (model B)	35.6	.938	775.7	.098
Four-m walk: usual pace				
Meters per second/1 unit ABI (model A)	0.337	< .001	0.353	< .001
Meters per second/1 unit ABI (model B)	0.003	.992	0.350	.235
Four-m walk: fastest pace				
Meters per second/1 unit ABI (model A)	0.455	< .001	0.462	< .001
Meters per second/1 unit ABI (model B)	0.359	.376	0.101	.807
PAD patients only (n = 127)				
Six-min walk				
Feet/1 unit ABI (model A)	755.0	< .001	832.4	< .001
Feet/1 unit ABI (model B)	247.1	.648	592.8	.295
Four-m walk: usual pace				
Meters per second/1 unit ABI (model A)	0.239	.029	0.464	< .001
Meters per second/1 unit ABI (model B)	–0.338	.317	0.794	.027
Four-m walk: fastest pace				
Meters per second/1 unit ABI (model A)	0.413	.011	0.703	< .001
Meters per second/1 unit ABI (model B)	–0.107	.825	0.808	.118

All analyses were performed within leg with lower ABI, defined by averaging dorsalis pedis and posterior tibial arterial pressures in each leg.

nificance were highest when method #3 was used to define the leg with the lower ABI. Therefore, in subsequent analyses, method #3 was used to define the leg with the lower ABI. In all comparisons, the higher ABI added little to the association between the lower ABI and functioning. This finding suggests that the functional level of a PAD patient correlates with the leg having the lower ABI, regardless of the ABI level in the opposite leg.

Subsequent analyses performed within the leg with the lower ABI showed that the ABI calculated by averaging arterial pressures from the dorsalis pedis and posterior tibial arteries (method #3) was consistently more predictive of leg functioning than the ABIs calculated through use of method #1 and method #2. Taken together, our results suggest that when leg functioning in PAD is being assessed, arterial pressures in the dorsalis pedis and posterior tibial arteries in each leg should be measured and averaged. The lower of the two values—the right leg or the left leg—is most predictive of objectively measured leg functioning.

We excluded individuals with calcified lower extremity arteries, as evidenced by an ABI greater than 1.50 in any patient or an ABI greater than 0.90 in a patient with VL-documented PAD. Therefore, our findings are not generalizable to these subsets of patients. Our cohort included a substantial proportion of participants with diabetes who may have had occult arterial calcification. Our findings were not altered when the diabetic participants were excluded and the analyses were rerun, which suggests that including diabetic patients did not substantially alter our findings. We also excluded 2% of participants with one or more ABI values of 0, and therefore our results may not be generalizable to this relatively small subset of patients. However, our results were not changed when the data were reanalyzed to include participants with 1 or more ABI values of 0.

Our outcome measures, 6-minute walk distance and 4-m walking velocity, were chosen because they are expected to reflect activity and functioning during daily living. The 6-minute walk is highly correlated with physical activity in PAD patients.[14] Among 64 patients with intermittent claudication, performance on the 6-minute walk was highly correlated with distance to onset of claudication pain ($r = 0.346$; $P = .007$) and with maximal claudication pain ($r = 0.525$; $P < .001$).[14] We previously reported that ABI was associated significantly with distance achieved in the 6-minute walk, independently of age, sex, race, and comorbidities known to affect lower extremity functioning. Because the 6-minute walk is a test of submaximal exercise intensity, it may measure activity and functioning during daily living better than a treadmill test that assesses maximal exercise intensity.[14] Four-meter walking velocity is highly correlated with risk of functional loss in the community.[17] Among 1112 nondisabled, community-dwelling men and women aged 71 years and older, walking velocity over 8 ft predicted mobility loss and disability at 4-year follow-up.[17] Therefore, our outcome measures are relevant to functioning during daily living.

There are at least two potential explanations for our finding that method #3 is the optimal way to calculate ABI when assessing lower extremity functioning. First, the average of the dorsalis pedis and posterior tibial arterial pressures may best reflect total perfusion to the more diseased lower extremity. Second, when the two pressures are averaged to calculate ABI, random variation and measurement error intrinsic to measures of arterial pressure are minimized, the result being closer association of the average ABI with functioning. Interestingly, although method #3 was more closely associated with functioning than method #1 or method #2, the leg with the lower ABI was consistently more predictive of leg functioning than the leg with the higher ABI. Furthermore, the average of all four ABIs was less predictive of functioning than method #3 in the leg with the lower ABI. These data show that the leg with the higher ABI does not add to the association between the leg with the lower ABI and lower extremity functioning. Functional limitations within the leg with greater arterial disease are not substantially influenced by the leg with less arterial disease.

Our results have important implications for those who measure ABIs for clinical and research purposes. However, our findings are not generalizable to outcomes other than functioning in PAD, such as mortality, cardiovascular events, and progression of lower extremity arterial ischemia. Future research is needed to determine the method of ABI calculation most predictive of lower extremity arterial ischemia progression and cardiovascular events in PAD. On the basis of our findings, future guidelines for diagnosis of PAD with the ABI should include specific recommendations for the optimal method of ABI calculation.

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