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Screening for Lower-Extremity Peripheral Artery Disease Using the Ankle-Brachial Index in Outpatient Practice: A 320-Patient Study

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Abstract

Introduction: Lower-extremity peripheral artery disease (PAD) is an important marker of cardiovascular risk and is frequently underdiagnosed. This study estimated the prevalence of low ankle-brachial index (ABI) among patients selected for ABI measurement in a cardiovascular outpatient centre in Dakar and explored associated clinical characteristics. **Methods:** This retrospective cross-sectional study included 320 adults who underwent bilateral ABI measurement between 1 January 2021 and 30 October 2022. ABI testing was ordered at the treating cardiologist's discretion for symptoms or signs suggestive of PAD, established cardiovascular disease, or an elevated cardiovascular risk profile. For each leg, the higher dorsalis pedis or posterior tibial systolic pressure was divided by the higher of the two brachial systolic pressures; the lower of the two leg ABIs was retained for patient-level classification. Low ABI was defined as <0.90, normal ABI as 0.90 to <1.30, and high ABI as ≥1.30. The multivariable analysis used complete cases (n = 289). **Results:** Among 1,176 outpatient attendees, 320 (27.2%) underwent ABI measurement and constituted the study sample. Low patient-level ABI was identified in 98/320 patients (30.6%), normal ABI in 221/320 (69.1%), and bilateral high ABI in 1/320 (0.3%). Six patients (1.9%) had a high ABI in at least one limb. In multivariable analysis, age ≥ 81 years was associated with low ABI (adjusted OR = 8.91; 95% CI: 1.01 - 78.91; p = 0.049). An inverse association with BMI-defined obesity was also observed (adjusted OR = 0.33; 95% CI: 0.14 - 0.76; p = 0.010) and should be interpreted cautiously. **Conclusion:** Low ABI was frequent among the selected outpatients who underwent ABI measurement, particularly among the oldest patients. These findings describe detection within a clinically selected cardiovascular population and do not estimate prevalence among all outpatient attendees or demonstrate that routine ABI screening prevents complications.

Keywords

Peripheral Artery Disease, Ankle-Brachial Index, Outpatient Practice, Screening, Cardiovascular Risk

1. Introduction

Lower-extremity peripheral artery disease (PAD) is one of the main clinical manifestations of systemic atherosclerosis. It corresponds to obstructive disease of the arteries located between the terminal aorta and the distal arteries of the lower limbs. Beyond its local impact, dominated by intermittent claudication, critical limb ischemia, and the risk of ulceration, gangrene, or amputation, PAD is above all a powerful marker of overall cardiovascular risk. Its presence often reflects diffuse atheromatous disease, also involving the coronary, cerebrovascular, carotid, or renal arterial territories [1]-[5].

PAD represents the third most common location of atherosclerosis after coronary and cerebrovascular disease. Its prevalence increases with age and exposure to cardiovascular risk factors, particularly smoking, diabetes, hypertension, dyslipidemia, and physical inactivity [6]-[10]. However, it remains largely underdiagnosed, as a substantial proportion of patients are asymptomatic or present with atypical symptoms. This under-recognition is concerning because patients with PAD, even when asymptomatic, have an increased risk of myocardial infarction, stroke, and cardiovascular mortality [11]-[14].

The ankle-brachial index is a simple, non-invasive, and low-cost first-line physiological test for detecting lower-extremity PAD. Contemporary guidelines recommend its use in patients with suggestive history or examination findings and consider screening reasonable in selected high-risk populations [3] [15]-[18].

In Senegal, evidence from cardiovascular outpatient practice remains limited. The primary objective of this study was to estimate the prevalence of low ABI among patients selected for ABI measurement in a cardiovascular outpatient centre. The secondary objective was to explore clinical characteristics associated with low ABI within this measured cohort.

2. Methods

This was a cross-sectional, descriptive, and analytical study with retrospective data collection, conducted from 1 January 2021 to 30 October 2022, over a 22-month period, at the Dr Ibra Mamadou Wane Medical Centre, a private cardiovascular care facility located in Dakar. The centre includes an outpatient consultation and functional investigations unit, as well as a cardiac rehabilitation unit.

Men and women aged at least 18 years with bilateral recorded ABI values were included. Patients with incomplete bilateral ABI results were not included. Individual-level demographic and cardiovascular-risk data were not extracted for the 856 attendees who did not undergo ABI measurement; therefore, tested and untested attendees could not be compared.

Data were collected from medical records using a standardised data extraction form. The variables studied included sociodemographic data, namely age, sex, place of residence, occupation, and socioeconomic status; anthropometric data, including weight, height, body mass index, and waist circumference; cardiovascular risk factors, including hypertension, diabetes, dyslipidemia, smoking, abdominal obesity, and physical inactivity; and cardiovascular history.

ABI measurement was performed after at least 10 minutes of rest in the supine position. Systolic pressure was measured in both brachial arteries and at the dorsalis pedis and posterior tibial arteries of both lower limbs using a non-directional continuous-wave Contec handheld vascular Doppler equipped with an 8 MHz probe. For each leg, ABI was calculated by dividing the higher of the dorsalis pedis and posterior tibial systolic pressures by the higher systolic pressure from the two arms. The lower of the right and left leg ABIs was retained for patient-level classification.

Low ABI was defined as a patient-level ABI < 0.90, normal ABI as 0.90 to <1.30, and high ABI as ≥ 1.30. Data were analysed using SPSS version 18. Categorical variables were compared using Pearson's chi-square test; Fisher's exact test was used when expected cell counts were small. For variables with more than two categories, one overall p-value was reported. The multivariable logistic-regression model was exploratory and included hypertension, diabetes, smoking, age $\geq$ 81 years, physical inactivity, BMI-defined obesity, sex, and abdominal obesity, selected a priori for clinical relevance and availability. The reference groups were the absence of the listed risk factor, age $\leq$ 80 years, male sex, and no abdominal obesity, as applicable. The model used complete cases ($n = 289$); missing BMI and waist-circumference values were not imputed. The history of stroke was not entered because only four participants had this history, making the adjusted estimate unstable. Statistical significance was set at $p < 0.05$.

3. Results

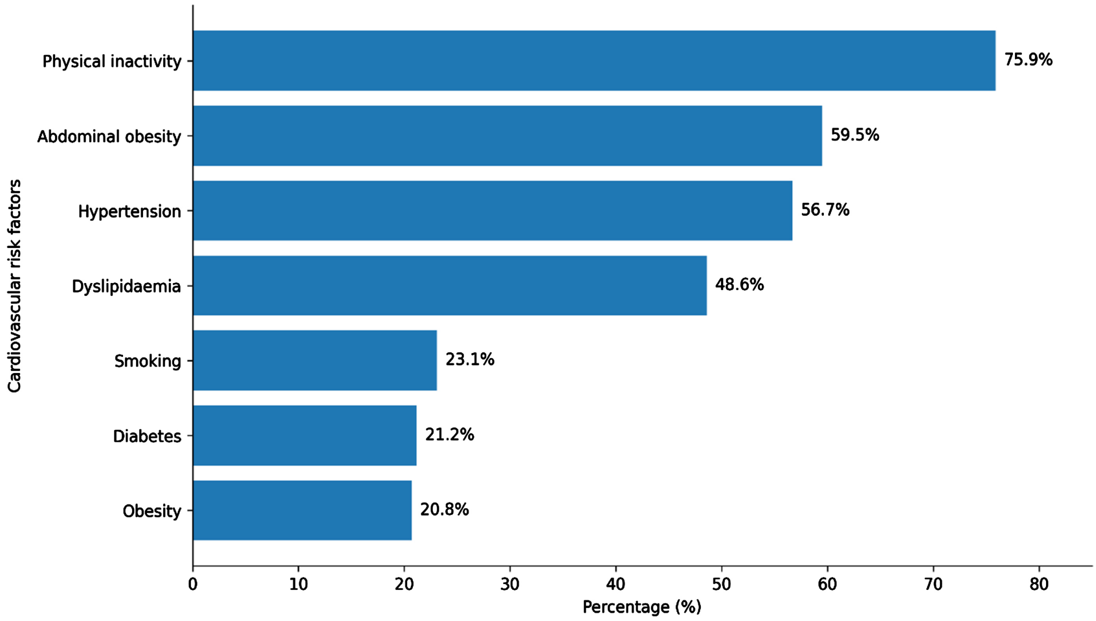
During the study period, 1,176 patients attended the facility, and 320 clinically selected patients underwent bilateral ABI measurement, corresponding to a measurement frequency of 27.2%. The remaining 856 attendees were not included in the analytical dataset and could not be compared with those tested. Mean age in the ABI-measured cohort was 56.7 years ± 12.8 years (range 21 - 86 years). The largest age group was 51 - 60 years (93/320; 29.1%). The population was almost equally distributed by sex, with 161 men (50.3%) and 159 women (49.7%), corresponding to a male-to-female sex ratio of 1.01. Most patients came from the Dakar suburbs (48.4%), followed by central Dakar (37.4%) and other regions (14.2%).

Regarding occupational status, informal sector 50.6%, retired 24.1%, formal sector 16.9%, and unemployed 8.4%. Socioeconomic status was middle in 60.1% of patients, low in 34.3%, and high in 5.7% (Table 1).

Table 1. Sociodemographic and clinical characteristics of the ABI-measured cohort.

Variable	Total
Total Sample Size	320 (100.0%)
Mean Age, Years	56.7 ± 12.8
Age Group, Years, n (%)	
21 - 30	5 (1.6%)
31 - 40	31 (9.7%)
41 - 50	65 (20.3%)
51 - 60	93 (29.1%)
61 - 70	82 (25.6%)
71 - 80	36 (11.3%)
≥81	8 (2.5%)
Sex, n (%)	
Men	161 (50.3%)
Women	159 (49.7%)
Geographical Origin, n/N (%)	
Suburbs	154/318 (48.4%)
Dakar	119/318 (37.4%)
Regions	45/318 (14.2%)
Missing	2/320 (0.6%)
Occupation, n (%)	
Formal sector	54 (16.9%)
Informal sector	162 (50.6%)
Retired	77 (24.1%)
Unemployed	27 (8.4%)
Socioeconomic Status, n/N (%)	
Low	109/318 (34.3%)
Middle	191/318 (60.1%)
High	18/318 (5.7%)
Mean BMI, kg/m^2	26.53
Obesity, n/N (%)	60/289 (20.8%)
Abdominal obesity, n/N (%)	172/289 (59.5%)
Intermittent claudication, n (%)	2 (0.6%)

Cardiovascular risk factors were frequent. Physical inactivity was found in 75.9% of patients, hypertension in 56.7%, dyslipidemia in 48.6%, smoking in 23.1%, and diabetes in 21.2%. Mean body mass index, calculated in 289 patients, was 26.53 kg/m^2, with an obesity prevalence of 20.8%. Abdominal obesity was found in 59.5% of patients with available waist circumference measurements. A history of coronary artery disease was reported in 15.3% of patients and a history of stroke in 1.3% (**Figure 1**).



Note: BMI-defined obesity and abdominal-obesity results are based on 289 participants with available measurements, although the complete cohort comprised 320 participants.

Figure 1. Distribution of cardiovascular risk factors in the ABI-measured cohort (n = 320).

Among the 320 patients who underwent ABI measurement, 98 had a low patient-level ABI (<0.90), corresponding to 30.6%. Mutually exclusive patient-level categories based on the lower of the two leg ABIs were low in 98/320 (30.6%), normal in 221/320 (69.1%), and high in 1/320 (0.3%) (**Figure 2**). At the limb level, six patients (1.9%) had ABI ≥ 1.30 in at least one limb: five had a unilateral high ABI with a normal contralateral ABI, and one had bilateral high ABI. No patient had a low ABI in one limb and a high ABI in the contralateral limb. The left lower limb was more frequently affected, and low artery-level ratios were more often recorded at the posterior tibial than the dorsalis pedis artery.

Low ABI was slightly more frequent in men than women (31.1% versus 30.2%; $p = 0.866$). The distribution differed across the seven age groups in an overall chi-square test ($p = 0.016$), and low ABI was present in 6/8 patients aged ≥ 81 years (75.0%) (**Figure 3**; **Table 2**). In the complete-case multivariable model (n = 289), age ≥ 81 years was associated with low ABI (adjusted OR = 8.91; 95% CI: 1.01 - 78.91; $p = 0.049$). BMI-defined obesity showed an inverse association (adjusted OR = 0.33; 95% CI: 0.14 - 0.76; $p = 0.010$); this unexpected finding should be interpreted cautiously because of selection, missing anthropometric data, and the retrospective design (**Table 3**).

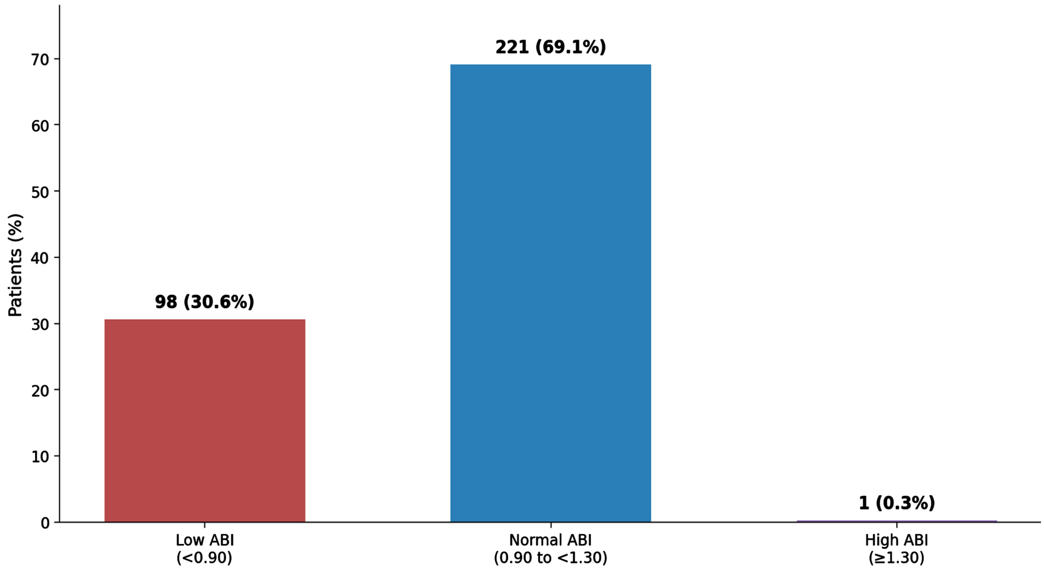


Figure 2. Mutually exclusive patient-level ABI categories based on the lower of the two leg ABIs (n = 320).

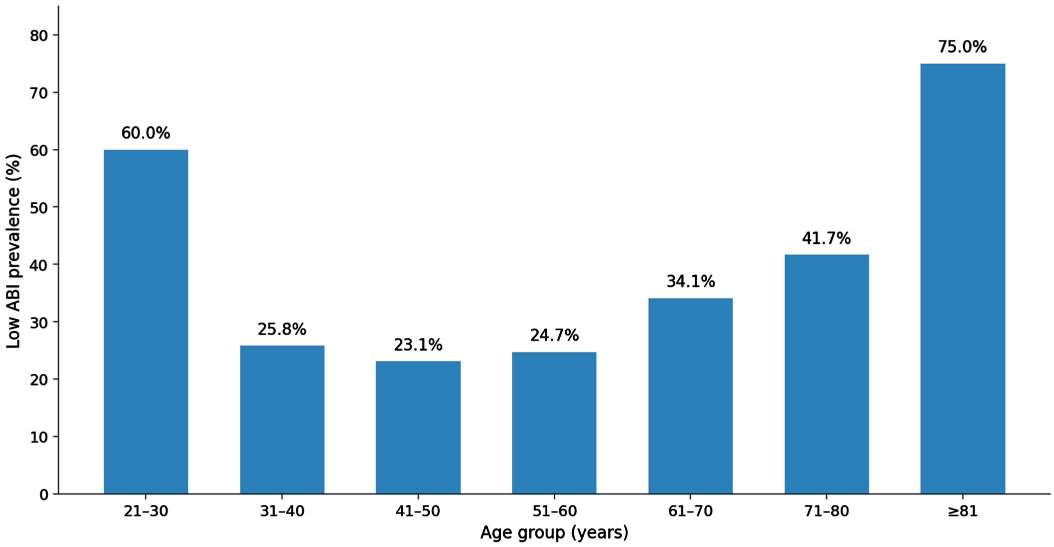


Figure 3. Prevalence of low ABI according to age group.

Table 2. Bivariate comparisons according to low ABI status.

Variable	Low ABI n (%)	No Low ABI n (%)	Total	Overall p-Value
Age Group, Years				0.016
21 - 30	3 (60.0%)	2 (40.0%)	5	
31 - 40	8 (25.8%)	23 (74.2%)	31	
41 - 50	15 (23.1%)	50 (76.9%)	65	
51 - 60	23 (24.7%)	70 (75.3%)	93	
61 - 70	28 (34.1%)	54 (65.9%)	82	

Continued

71 – 80	15 (41.7%)	21 (58.3%)	36	
≥81	6 (75.0%)	2 (25.0%)	8	
Sex				0.866
Women	48 (30.2%)	111 (69.8%)	159	
Men	50 (31.1%)	111 (68.9%)	161	
Residence				0.051
Suburbs	37 (24.0%)	117 (76.0%)	154	
Dakar	44 (37.0%)	75 (63.0%)	119	
Regions	16 (35.6%)	29 (64.4%)	45	
Occupation				0.063
Formal sector	21 (38.9%)	33 (61.1%)	54	
Informal sector	41 (25.3%)	121 (74.7%)	162	
Retired	30 (39.0%)	47 (61.0%)	77	
Unemployed	6 (22.2%)	21 (77.8%)	27	
Socioeconomic Status				0.570
High	6 (33.3%)	12 (66.7%)	18	
Middle	54 (28.3%)	137 (71.7%)	191	
Low	37 (33.9%)	72 (66.1%)	109	
Smoking				0.068
Yes	29 (39.2%)	45 (60.8%)	74	
No	69 (28.0%)	177 (72.0%)	246	
Hypertension				0.360
Yes	52 (28.6%)	130 (71.4%)	182	
No	46 (33.3%)	92 (66.7%)	138	
Diabetes				0.067
Yes	27 (39.7%)	41 (60.3%)	68	
No	71 (28.2%)	181 (71.8%)	252	
Dyslipidaemia				0.018
Yes	38 (24.4%)	118 (75.6%)	156	
No	60 (36.6%)	104 (63.4%)	164	
Physical Inactivity				0.654
Yes	76 (31.3%)	167 (68.7%)	243	
No	22 (28.6%)	55 (71.4%)	77	

Continued

BMI-Defined Obesity				0.002
Yes	8 (13.3%)	52 (86.7%)	60	
No	78 (34.1%)	151 (65.9%)	229	
Coronary Artery Disease				0.093
Yes	20 (40.8%)	29 (59.2%)	49	
No	78 (28.8%)	193 (71.2%)	271	
History of Stroke				1.000
Yes	1 (25.0%)	3 (75.0%)	4	
No	97 (30.7%)	219 (69.3%)	316	

Values are n (row %) unless otherwise specified. Each p-value is the single overall Pearson chi-square test for the variable; Fisher's exact test was used for the history of stroke because of sparse cells. ABI, ankle-brachial index.

Table 3. Exploratory multivariable model for low ABI (complete cases, n = 289).

Variable	Adjusted OR	95% CI	p-Value
Hypertension	0.75	0.43 - 1.30	0.310
Diabetes	1.66	0.88 - 3.13	0.120
Smoking	1.53	0.77 - 3.04	0.230
Age ≥ 81 years	8.91	1.01 - 78.91	0.049
Physical Inactivity	0.99	0.52 - 1.89	0.980
BMI-Defined Obesity	0.33	0.14 - 0.76	0.010
Female sex	1.30	0.67 - 2.53	0.430
Abdominal obesity	1.09	0.60 - 2.00	0.780

Outcome: patient-level ABI < 0.90. Reference groups: no hypertension, no diabetes, non-smoker, age ≤ 80 years, physically active, no BMI-defined obesity, male sex, and no abdominal obesity. Missing BMI and waist-circumference values were handled by complete-case analysis without imputation. The history of stroke was excluded because only four participants had this history. OR, odds ratio; CI, confidence interval; ABI, ankle-brachial index.

4. Discussion

This study found a high frequency of low ABI among patients selected for ABI measurement in a cardiovascular outpatient centre in Dakar. Nearly one in three tested patients had ABI < 0.90. This proportion applies only to the clinically selected ABI-measured cohort and should not be interpreted as prevalence among all 1,176 outpatient attendees or in the general population. The findings support the feasibility of targeted ABI assessment in patients whose symptoms, signs, established cardiovascular disease, or risk profile raise clinical concern [3] [15].

The observed 30.6% prevalence of low ABI is higher than estimates from several population-based studies, but the difference is consistent with the selection process. ABI was ordered at the cardiologist's discretion, and the measured cohort was enriched for cardiovascular symptoms, established disease, and risk factors, including physical inactivity, hypertension, dyslipidemia, diabetes, smoking, and abdominal obesity. This selection limits direct comparison with unselected populations and may also influence the observed associations between risk factors and low ABI.

Age was the main characteristic associated with low ABI. The proportion reached 75.0% among patients aged ≥ 81 years, and this age category remained associated with low ABI in the exploratory multivariable model. This finding is consistent with international evidence showing increasing PAD prevalence with age [3] [6] [17]-[20]. However, the wide confidence interval reflects the small number of participants in the oldest category, and the estimate should be considered imprecise.

The difference according to sex was small and not statistically significant. The measured cohort was almost evenly divided between women and men, and the confidence interval from the adjusted model was compatible with both lower and higher odds in women. Accordingly, the present data do not support a sex-specific conclusion [21]-[25].

The inverse association between BMI-defined obesity and low ABI should not be interpreted as protective. It may reflect clinical selection, residual confounding by age or disease severity, missing anthropometric data, or reverse causation in older or frail patients. BMI also does not fully capture cardiometabolic adiposity, and simultaneous inclusion of BMI-defined and abdominal obesity may have reduced estimate stability. This result is exploratory and requires confirmation in a prospectively defined cohort [26]-[30].

This study has several limitations. ABI measurement was performed in only 320 of 1,176 attendees according to clinical judgement rather than systematic sampling. Individual-level data were unavailable for the 856 untested attendees, so differences in age, sex, symptoms, or cardiovascular-risk profile could not be assessed. The reported 30.6%, therefore, represents prevalence among patients who received ABI measurement and is not generalizable to all outpatient attendees. The retrospective design exposed the study to missing and imperfectly recorded data; BMI and waist circumference were unavailable for 31 participants and were handled by complete-case analysis without imputation. The single-centre cardiovascular setting and clinically selected population also limit external validity and may bias associated-factor estimates. The multivariable model was exploratory, the ≥81-year subgroup was small, and no independent anatomical confirmation was systematically available. Finally, the study did not evaluate treatment, complications, or clinical outcomes, and cannot establish that routine ABI measurement improves prognosis. Its principal contribution is to describe low-ABI detection and associated risk profiles in a selected outpatient cohort.

5. Conclusions

Low ABI was frequent among the clinically selected patients who underwent measurement in this Dakar cardiovascular outpatient centre. The 30.6% estimate applies to the ABI-measured cohort and not to all outpatient attendees. Low ABI was slightly more frequent in men, without a significant sex difference, and age ≥ 81 years was the principal associated characteristic, although the estimate was imprecise.

These findings support targeted ABI measurement when symptoms, signs, established cardiovascular disease, or an elevated risk profile justify assessment. They do not demonstrate that routine testing of all attendees prevents complications or improves clinical outcomes. Prospective multicentre studies using predefined selection criteria, complete covariate measurement, confirmatory vascular imaging when indicated, and longitudinal follow-up are needed to define population burden and evaluate the clinical value of ABI-based screening strategies in Senegal.

Author Contributions

Conceptualization: AAN and NDG. Formal analysis: PF. Methodology: AAN and NDG. Writing—original draft: NDG and AAN. Visualization: NDG. Writing—review and editing: all authors. All authors critically revised the manuscript, approved the final version and agreed to be accountable for the work.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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