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Discrepancies in Peripheral Arterial Function Indices Among Healthy Young Black Africans: Findings from Pilot Study Interpreted Using AHA Reference Values

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Abstract

Background Accumulating evidence points to a rise in the incidence of peripheral arterial diseases (PAD) among young adults in Sub-Saharan Africa (SSA) highlighting the need for assessing peripheral arterial function (PAF) in this demographic. Current research from Asian populations suggests that established cut-off values for diagnosing PAD—using assessment parameters, such as Ankle-Brachial Index (ABI), Toe-Brachial Index (TBI), and Pulse Volume Waveform (PVW)—may not accurately represent population-specific reference values. This study evaluates these parameters in a carefully selected population of healthy young black Africans, using American Heart Association (AHA) reference values for ABI and TBI to assess their agreement in classifying normal and abnormal readings compared to PVW. The results were also analyzed across sex and between the left and right sides.

Methods We carefully and systematically recruited 156 healthy black Africans aged 18–35 years with no characteristics indicative of peripheral arterial dysfunction. An automated device that use oscillometry and photoplethysmography, concurrently measured ABI, TBI, and PVW in a controlled environment. The visual comparison and Student's *t* test were employed to compare these values with the AHA references.

Results Approximately 19.1% ($n=23$) of participants had an ABI < 0.9, and 41.3% ($n=50$) had a TBI < 0.7 in at least one limb, indicating abnormally low peripheral arterial indices according to AHA criteria. The prevalence of ABI < 0.9 was higher in the left leg (17.4%) compared to the right leg (6.6%), and among males (18.7%) compared to females (15.3%). Similarly, TBI < 0.7 was more prevalent in the left leg (33.9%) than the right leg (24.8%), and higher in females (40.4%) than males (28.1%). Notably, 91% of participants with ABI < 0.9 in the right leg and 97% in the left leg had normal (grade A) PVWs, while 97.6% of those with TBI < 0.7 also had grade A PVWs.

Conclusion Healthy young black Africans' ABI and TBI values differed between the right and left legs. A significant proportion of individuals classified as abnormal according to ABI had normal PVWs based on AHA criteria. These findings highlight the need to carefully interpret ABI results in young populations and emphasize the importance of concurrent ABI and PVW measurements. Larger studies are warranted to refine population-specific reference ranges and explore right–left differences' physiological and clinical implications.

Keywords Ankle-Brachial Index, ABI, Toe-Brachial Index, TBI, Pulse volume waveforms, Peripheral arterial function, Sex differences, AHA reference values

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1 Background

The primary function of arteries is to supply blood, oxygen, and nutrients to the peripheral tissues and organs [1]. Peripheral arteries, which supply the lower limbs, are equally important and substantially contribute to the overall functioning of arteries [1, 2]. Therefore, proper arterial functions are attained when the peripheral arteries function normally. Several factors, commonly atherosclerosis, may compromise arterial function and cause progressive arterial narrowing, which if left unchecked, may lead to total blockage [3]. Peripheral arterial function (PAF) naturally changes with age, making its assessment across the lifespan essential [4, 5]. Interestingly, recent reports have highlighted a higher prevalence of peripheral arterial diseases (PAD) among younger populations in lower middle-income countries (LMICs) including Tanzania (3.1% among men and 2.7% among women) compared to high-income countries (1·3% among men and 2.2% among women) and worldwide (2.9% among men and 2.7% among women) prevalences [6]. This underscores the importance of assessments for early detection and intervention in LMICs.

Non-invasive methods have been useful in assessing the peripheral arterial status and diagnosing PAD [2, 3]. They include segmental arterial blood pressure measurements [Ankle-Brachial Index (ABI) and Toe-Brachial Index (TBI)], the Doppler ultrasound waveform which is the gold standard, and Pulse Volume Waveforms (PVWs) [2, 3]. ABI, TBI, and PVWs are cost-effective and simple; hence, they are preferred for the initial assessment of PAF and screening for PAD [3, 7]. Invasive approaches like contrast angiography are more accurate, however, given their intensiveness and cost, these methods are often reserved for confirmation, mostly before surgical intervention [3].

Both ABI and TBI have been validated using gold-standard methods to assess PAF and PAD and found to be accurate, reliable, and reproducible [8, 9]. TBI is more reliable than ABI in assessing PAF, especially in calcified vessels, since incompressibility due to calcification falsely causes high ABI [10]. The toe blood vessels are usually unaffected by systemic calcification [10]. An ABI of 1.0–1.3 and a TBI > 0.7 are considered normal and have been shown to predict both adverse events and mortality. A resting ABI of 0.9–0.99 is stated as borderline [11]. Peripheral arterial status can further be determined using Pulse Volume Waveforms (PVW), which are analyzed based on their quality, shapes, and amplitude, and then graded and interpreted based on defined standards, whereby grade A is considered normal, while grades B–D signify abnormalities of varying severities [12, 13].

Advances in technology have led to the development of automated oscillometric and photoplethysmographic (PPG) devices that can simultaneously measure the ankle-brachial index (ABI), toe-brachial index (TBI), and pulse volume waveforms (PVWs). These devices provide a reliable, user-friendly, and cost-effective alternative to traditional measurement methods, particularly in primary care settings of developing countries, where expertise in Doppler studies is often limited [14, 15]. By simultaneously measuring pressures in both limbs, these devices minimize potential temporal variations, thereby enhancing the accuracy of left–right comparisons. In the current study, we capitalized on the ability of these automated devices to compare peripheral arterial parameters between the left and right sides, allowing us to gain insights into possible variations in these indices across different demographic groups while reducing measurement bias. We assessed the utility of internationally recognized parameters—ABI, TBI, and PVWs—in a unique demographic of young, healthy black Africans using an automated digital device. ABI and TBI values were evaluated against the American Heart Association (AHA) criteria, which are widely referenced standards [11]. Particularly, the AHA guidelines do not directly address the applicability of ABI in young adults [16, 17]. Additionally, previous research has raised concerns about the reproducibility of ABI measurements in younger cohorts [18].

Therefore, our objective was to assess whether the AHA cut-offs for ABI and TBI apply to this population, investigate sex-related differences in these indices, and assess whether previously reported discrepancies in ABI and TBI between limbs [8, 19] are genuine or artifacts of temporal effects associated with manual measurement methods [20]. Ultimately, this research aims to stimulate further investigation into establishing common peripheral arterial function indices in healthy young black Africans.

2 Methods

2.1 Study Design, Participant Recruitment, and Data Collection Process

The study recruited 156 university students from May to June 2021. We used structured questionnaires to gather information on social demographics, lifestyle, and cardiovascular risk factors. These included the Global Physical Activity Questionnaire and the Edinburgh Claudication Questionnaire [21–23]. Anthropometric parameters, resting heart rate, and blood pressures (brachial, ankle, and toe) were measured, while PVWs were recorded at the same room temperature set at 23–24 °C.

2.2 Inclusion and Exclusion Criteria

The study aimed to recruit a cohort of apparently healthy young adult Africans (Fig. 1), aged 18–35 attending the university. The intent was to focus on individuals who demonstrated no clinical signs or symptoms indicative of peripheral arterial disease (PAD). Given that this was primarily a pilot study, the focus was on maximizing internal validity to inform the design of larger studies that would address external validity.

Inclusion criteria included young adults aged 18–35 years, and individuals who consume at least one portion of fruits and vegetables daily, indicating a basic nutritional awareness and dietary health. Additionally, participants were included if there was no self-reported history or clinical evidence of peripheral arterial disease assessed through structured questionnaires, including the Edinburgh Claudication Questionnaire.

Exclusion criteria included individuals with known peripheral arterial disease or symptoms indicative of PAD, those who had undergone revascularization or orthopedic surgeries involving a fixator that could influence vascular health, participants with a history of vascular diseases such as hypertension or diabetes, and individuals who reported current cigarette smoking.

2.3 Blood Pressure (BP) and Heart Rate (HR) Measurement

Participants sat and rested for 5 min before BP and resting HR measurements were taken using an automatic blood pressure monitor (Omron model M2 Basic HEM-7120-E). The cuff was placed above the cubical over the brachial artery, but sitting BP was only used to screen for inclusion and not for ABI and TBI determination.

2.4 Assessment of Peripheral Arterial Function (PAF)

Participants quietly rested supine for 10 min before the PAF assessment to allow recovery from potential white-coat blood pressure variations. Cuffs were wrapped 2 cm above the cubical for brachial pressure, 2 inches above the lateral malleolus for ankle pressure, and 2.5 cm wide

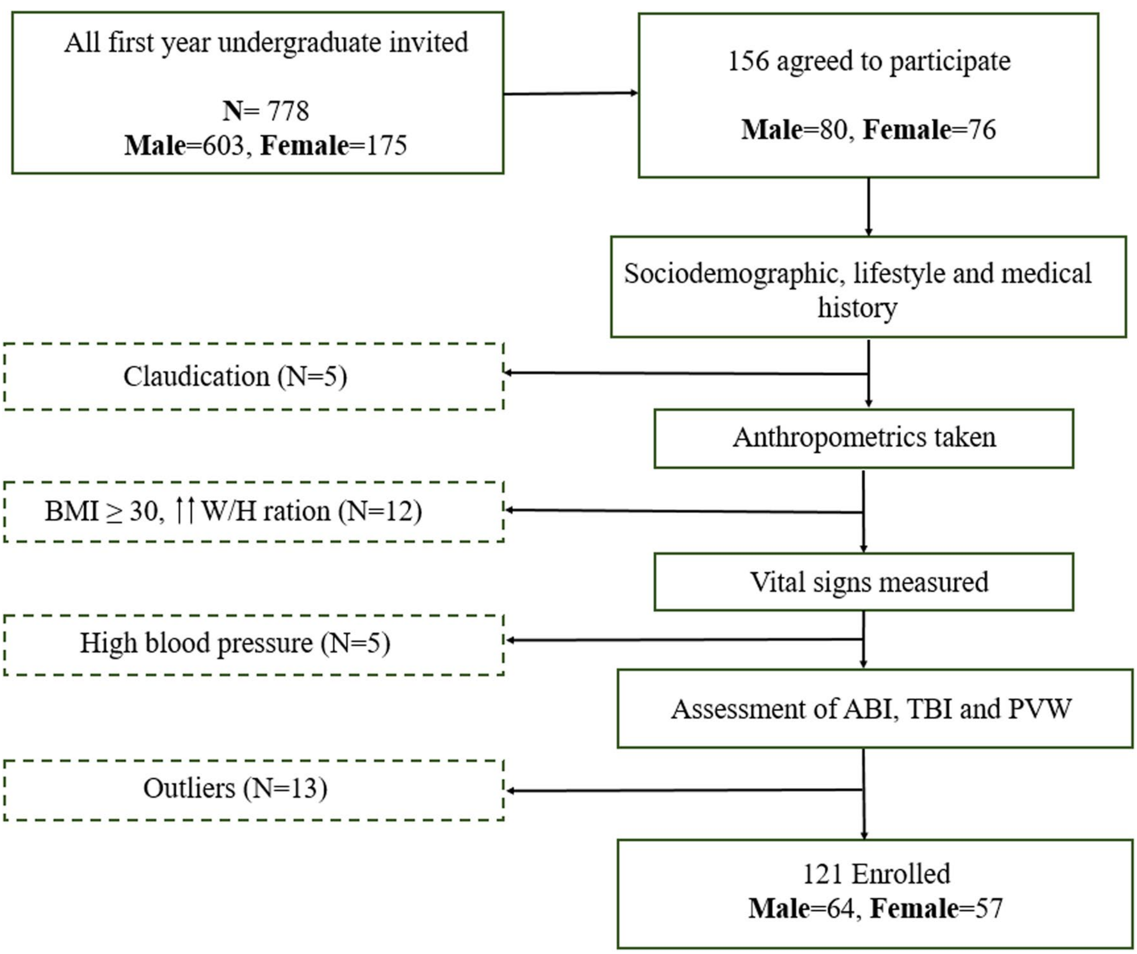

Fig. 1 Participants' recruitment process

over the great toe for toe pressure. For TBI, a photoplethysmography (PPG) probe was applied with the sensor in contact with the participant's skin. All cuffs and PPG were connected to an automated oscillometric device (Smartdop, XT, Kodymedics, India), which measured supine BPs (brachial, ankle, and toe) bilaterally, produced the PVWs and generated indices simultaneously. ABI and TBI were automatically computed. PAD was defined by ABI < 0.9 and PVWs of > grade B in at least one leg [24, 25]. Measurements were done once except if ABI was 0.9–1.0 when measurements were repeated two times and the smallest ABI was recorded.

PVWs were graded based on graphical shape (Fig. 2). A waveform was graded A and considered normal if it had a characteristic brisk systolic upstroke, a sharp systolic peak, a gradual downslope and a distinctive diastole dicrotic notch. Was graded B indicating mild PAD if it had a sharp peak but lacked a dicrotic notch and the downslope was hooked away from the baseline. Was graded C indicating moderate PAD if it had a flattened systolic peak and lacked a dicrotic notch with a reduction of amplitude and pulse elongation. Was graded D indicating PAD if it had severe amplitude reduction and pulse elongation.

2.5 Anthropometric Measurements

The study used a stadiometer and calibrated balanced weighing scale (Seca model 869,132,004, China) to measure height and weight, and BMI was calculated and used to classify weight [27]. Hip circumference (HC) and waist circumference (WC) were measured using a flexible inelastic tape measure, and the Waist-to-Hip Ratio (WHR) was calculated to determine central obesity [27, 28].

2.6 Validity and Reliability

The automated oscillometric method is endorsed for the measurement of ABI, TBI, and PVWs due to its over 90% accuracy, sensitivity, and specificity compared to the gold standard of Doppler ultrasound [2, 7]. Adhering to the manufacturer's instructions, which are similar to 2012 AHA recommendations [4, 15], oscillometric and PPG measurements were made using the Smartdop XT (Kodymedics, India), an automated device that measures ABI, TBI, and PVW. Blood pressures were obtained simultaneously from both arms (brachial artery) and both ankles (dorsalis pedis and posterior tibial arteries) using cuffs sized for the limb. The ABI was calculated as the ratio of ankle pressure to the higher of the two arm pressures. The parameters were measured concurrently bilaterally minimizing temporal bias and simultaneously producing PVWs similar to the gold standard Spectral Doppler ultrasound [25].

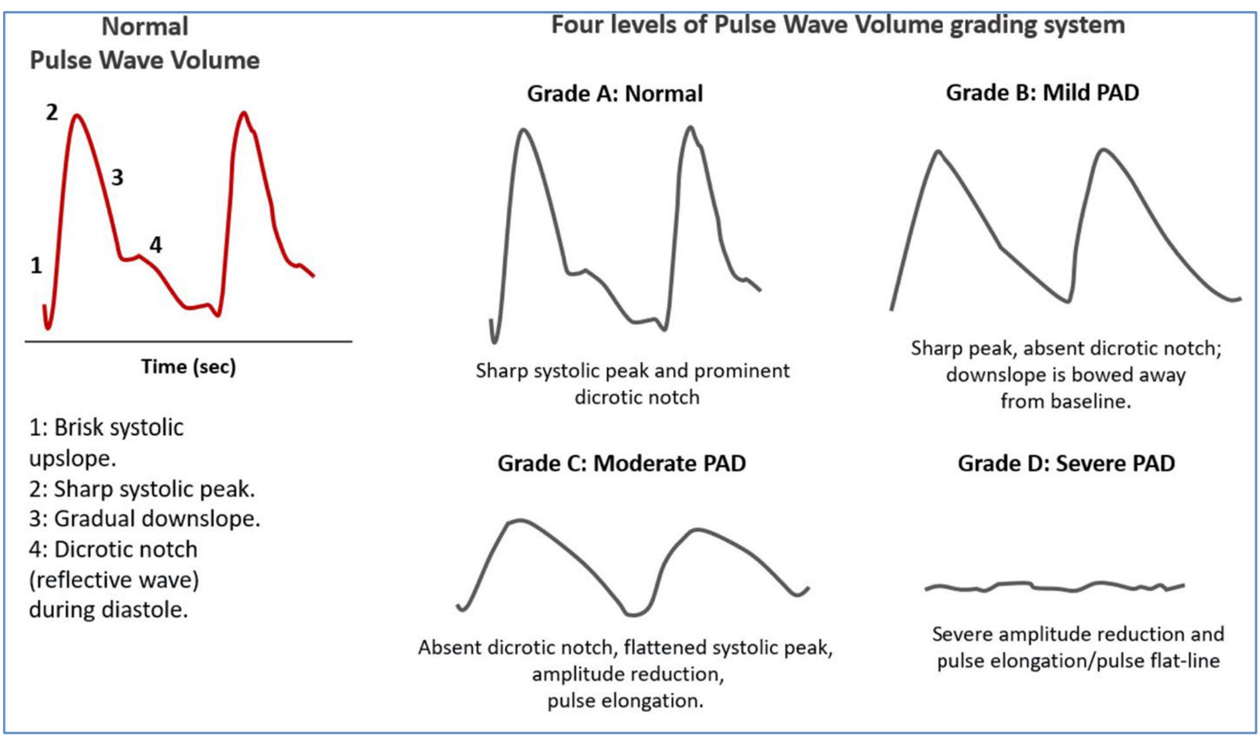

Fig. 2 Pulse volume waveforms grading criteria [26]

The device brand used in this study, though less validated in the literature compared to the device cited as an example of oscillometric measurement [7], has been clinically used for over a decade particularly in Asia [15]. Its affordability makes it a practical option in low- and middle-income (LMIC) settings where more expensive devices may be inaccessible. Given its cost and accessibility advantages, this device is increasingly being used in both research and clinical settings in low- and middle-income countries (LMICs) [29–31].

2.7 Data Analysis

The data were analyzed using Microsoft Excel and SPSS version 23. Normality was determined using the Shapiro–Wilk test. Descriptive results were expressed in frequency tables, mean, or median. Visual comparison was used to compare measurements with AHA references. The t test was used to compare ABI and TBI values between legs and sex. A p value of < 0.05 was considered statistically significant, but we adjusted for the multiple t tests (male–female and right–left comparisons) by the Bonferroni method; hence, only a p value of < 0.025 was considered significant for t test analysis.

2.8 Ethical Consideration

The MUHAS ethical review board approved the study and adhered to international ethics standards for research involving human subjects. Participants provided written consent, and those with pathological doubts were recommended for further medical assessment.

3 Results

3.1 Characteristics of the Study Participants

Of 156 who volunteered to participate, 121 participants of whom 64 (52.9%) were males, met the criteria and were included in this study (Fig. 1). The median age of study participants was 20 (IQR = 20–23). Most participants (84%) had no family history of diabetes or cardiovascular disease, 91% maintained adequate physical activity levels, and 94.2% had no history of alcohol consumption (Table 1).

The median BMI was 21.5 (IQR = 19.72–23.46) and the median WHR was 0.79 (IQR = 0.75–0.82) (Table 2). On the right arm, the mean sitting systolic BP was 118 ± 12 mmHg, the diastolic BP was 72 ± 8 mmHg, and the resting HR was 72 ± 11 beats/minute. On the left arm, the mean sitting systolic BP was 117 ± 13 mmHg, diastolic BP was 74 ± 8 mmHg, and resting HR was 72 ± 11 beats/minute.

3.2 Peripheral Arterial Function

3.2.1 Brachial, Ankle, and Toe BP of the Study Participants

All supine brachial BP (used for enrollment only) readings were within normal limits and were significantly higher in males (Table 3). The ankle systolic BP was significantly elevated in the right leg ($t(120) = 7.7$, $p < 0.001$) even when analyzed in sex categories. Also, the right toe systolic BP was significantly higher ($t(120) = 3$, $p = 0.004$) but not in sex categories. Moreover, males exhibited higher mean toe BP on the right ($t(119) = 2$, $p = 0.002$) and left legs ($t(119) = 2$, $p = 0.02$).

Table 1 Sociodemographic characteristics of the study participants

Variable	Category	Frequency (*n*)	Percent (%)
Age group (years)	18–25	105	86.8
	26–35	16	13.2
Median age in years (IQR)	20 (20, 23)		
Sex	Male	64	52.9
	Female	57	47.1
Marital status	Single	114	94.2
	Married	7	5.8
1st degree relative with hypertension	Yes	19	15.7
	No	102	84.3
1st degree relative with diabetes mellitus	Yes	14	11.6
	No	107	88.4
1st degree relative with cardiovascular disease	Yes	8	6.6
	No	113	93.4
Alcohol intake	Yes	5	4.1
	No	116	95.9
Physical activity in MET minutes per week	< 600 MET	10	8.5
	> 600 MET	107	91.5

Table 2 Anthropometric and sitting arm blood pressure characteristics of the study participants

Variable	Category	Frequency (*n*)		Percent (%)
BMI (Kg/m^2)	Underweight	13		10.7
	Normal	94		77.7
	Overweight	14		11.6
Median BMI in Kg/m^2 (IQR)	21.50 (19.72, 23.46)			
Height (cm)	< 150	3	2.5	
	150.00–160.00	33	27.3	
	160.01–170.00	60	49.6	
	170+	20	20.7	
Median height in cm (IQR)	164.05 (159,169.50)			
Waist-to-hip ratio (WHR)	Excellent	82		67.8
	Good	25		20.7
	Moderate	14		11.6
Median waist-to-hip ratio (WHR) (IQR)	0.79 (0.75–0.82)			
Resting heart rate (mean ± SD)	Right arm (Beat/min)	72 ± 11		
	Left arm (Beat/min)	72 ± 11		

Table 3 Arterial blood pressure of study participants on different anatomical points

	Male mean ± SD			Female mean ± SD		
	Systolic	Diastolic	MAP	Systolic	Diastolic	MAP
Enrollment BP (mmHg)						
Right	122 ± 11	73 ± 9	89 ± 8	112 ± 9	72 ± 6	85 ± 6
Left	122 ± 10	73 ± 8	90 ± 8	110 ± 9	73 ± 6	85 ± 6
Brachial pressure (mmHg)						
Right	131 ± 12			125 ± 10		
Left	129 ± 11			123 ± 10		
Ankle pressure (mmHg)						
Right	140 ± 14			136 ± 10		
Left	131 ± 11			129 ± 11		
Ankle Brachia Index (ABI)						
Right	1.06 ± 0.07			1.07 ± 0.09		
Left	0.99 ± 0.08			1.01 ± 0.09		
Toe pressure (mmHg)						
Right	105 ± 18			95 ± 15		
Left	99 ± 18			92 ± 20		
Toe Brachia Index (TBI)						
Right	0.79 ± 0.11			0.75 ± 0.11		
Left	0.75 ± 0.12			0.72 ± 0.15		

3.2.2 ABI and TBI of the Study Participants

The right mean ABI (1.06 ± 0.08) was higher ($t(120) = 8$, $p < 0.001$) than the left (1.00 ± 0.09) even when analyzed in sex categories (Fig. 3). The right mean TBI (0.77 ± 0.11) was higher ($t(120) = 3$, $p = 0.011$) on the left (0.74 ± 0.14), but was not significant when analyzed in sex categories.

3.2.3 Comparison of Observed ABI and TBI to AHA References

About 19% ($n = 23$) had ABI < 0.9 and 41.3% ($n = 50$) had TBI < 0.7 on at least one limb. Prevalence of ABI < 0.9 was higher on the left leg (17.4%) than the right (6.6%) and among males (18.7%) than females (15.3%). Prevalence of TBI < 0.7 was higher on the left leg (33.9%) than the right

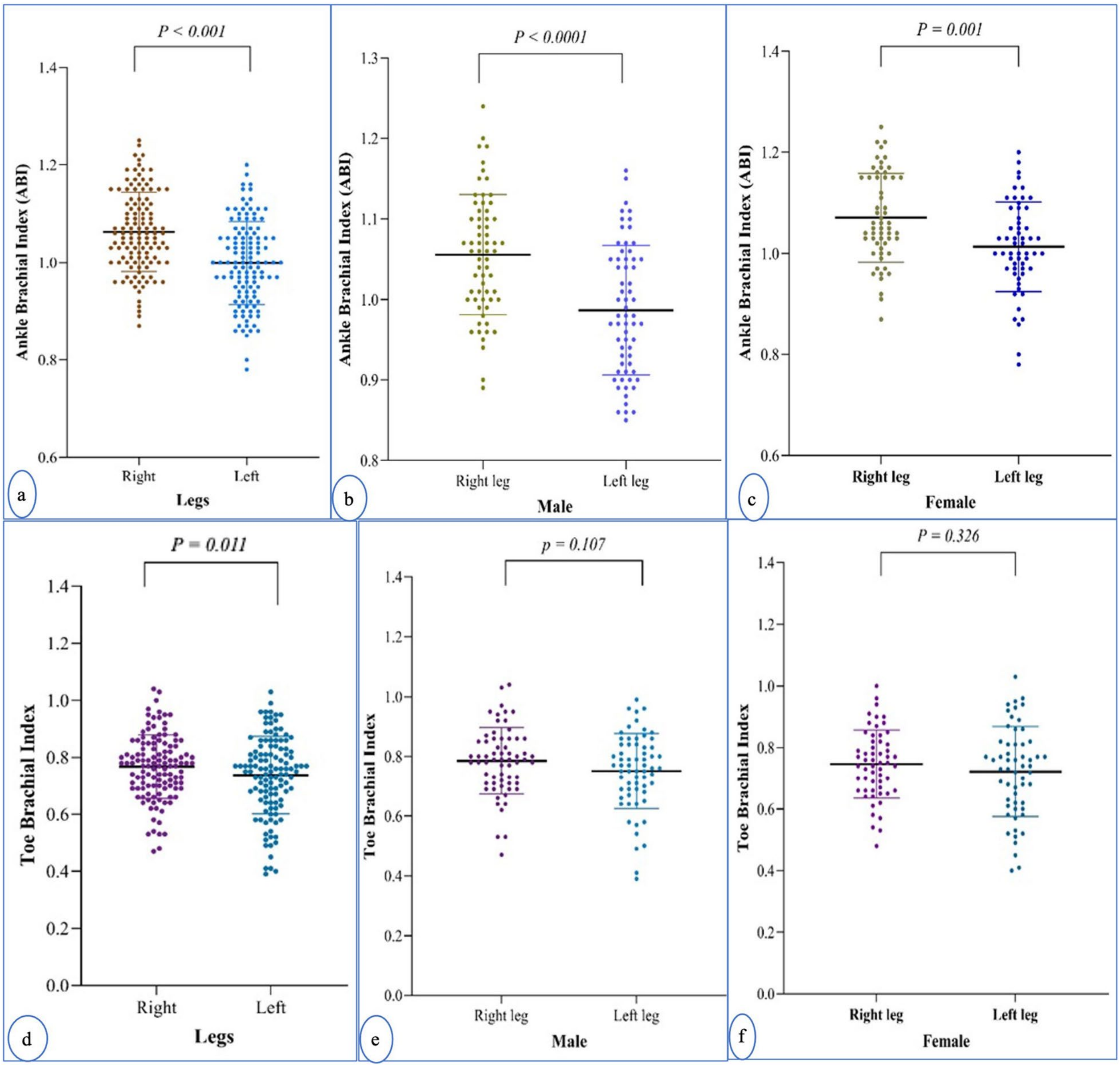

Fig. 3 Comparison of right and left leg mean and range of ABI [overall (**a**), males (**b**), and females (**c**)] and TBI [overall (**d**), males (**e**), and females (**f**)]

(24.8%) and among females (40.4%) than males (28.1%) (Table 4).

3.2.4 Pulse Volume Waveforms (PVWs) of the Study Participants

The majority (87%, $n = 105$) of participants exhibited triphasic waveforms (Fig. 4) in both toes which was 97% ($n = 117$) on the right ankle and 98% ($n = 118$) on the left. Grade A waveforms were prevalent, in both toes (88%) and ankles (97% right and 98% left). Interestingly, 1.2% (all males) exhibited grade C waveforms on the toe, but none on the ankle. About 91% of participants with ABI < 0.9 had grade A (normal) PVWs. Also, 98% of participants with TBI < 0.7 had grade A PVWs.

4 Discussion

This study employed a careful recruitment strategy to select apparently healthy individuals, ensuring a uniform population and minimizing confounding variables from diverse health conditions. Although this approach resulted in a smaller sample size, it provided a focused evaluation. This sets the stage for future, comprehensive assessments of ABI, TBI, and PVWs in young, healthy black Africans, thereby establishing a

Table 4 Crosstabulation of ABI and PVW grades

	PVW grade *n* (%)		
	A (normal)	**B (mild PAD)**	**C (moderate PAD)**
Right ankle			
ABI < 0.9	6 (75.0)	2 (25.0)	0 (0.0)
ABI > 0.9	96 (98.0)	2 (2.0)	0 (0.0)
Left ankle			
ABI < 0.9	19 (90.5)	2 (9.5)	0 (0.0)
ABI > 0.9	97 (99)	1 (1.0)	0 (0.0)
Right toe			
TBI < 0.7	23 (76.7)	7 (23.3)	0 (0.0)
TBI ≥ 0.7	84 (92.3)	7 (7.7)	0 (0.0)
Left toe			
TBI < 0.7	28 (68.3)	11 (26.8)	2 (4.9)
TBI ≥ 0.7	77 (96.3)	3 (3.7)	0 (0.0)

solid foundation for larger-scale research. This study identified significant differences in ABI and TBI values between the left and right sides, as well as sex-related variations in these vascular indices. Additionally, a significant number of individuals classified as normal were identified as having peripheral artery disease (PAD) when assessed using AHA references for ABI and TBI. This finding highlights potential discrepancies in the interpretation of these indices when established international standards for diagnosing PAD are applied to young, healthy individuals.

Consistently higher values were observed on the right side across the entire sample and within sex-categorized sub-analyses. Previous studies have noted similar right–left differences and consistent variations in brachial blood pressure [5, 18], which might suggest analogous asymmetries in ankle hemodynamics. The observed higher right-side ABI could be attributed to factors such as differences in collateral circulation and vascular anatomy between the sides. Previous studies have suggested that temporal trends, such as the order in which legs are measured, could explain right–left differences in ABI and TBI, with the first leg measured often showing a higher index [8, 19]. However, this study used simultaneous measurements to eliminate such temporal variations, leading us to hypothesize that anatomical and physiological factors, possibly related to left–right dominance [32, 33], may contribute to higher ankle BP on the right, thus affecting the observed higher right ABI. This finding underscores the need for a deeper understanding of peripheral vascular dynamics and the complex interplay of factors influencing blood pressure gradients across limbs. The consistent occurrence of significant differences highlights the importance of further detailed research and larger scale studies to elucidate their physiological underpinnings and clinical implications.

We observed significant sex differences in ABI and TBI, with males exhibiting higher mean systolic brachial blood pressures, which likely influence these indices. Contrary to expectations and previous reports suggesting higher ABIs in males [18], females in our study showed

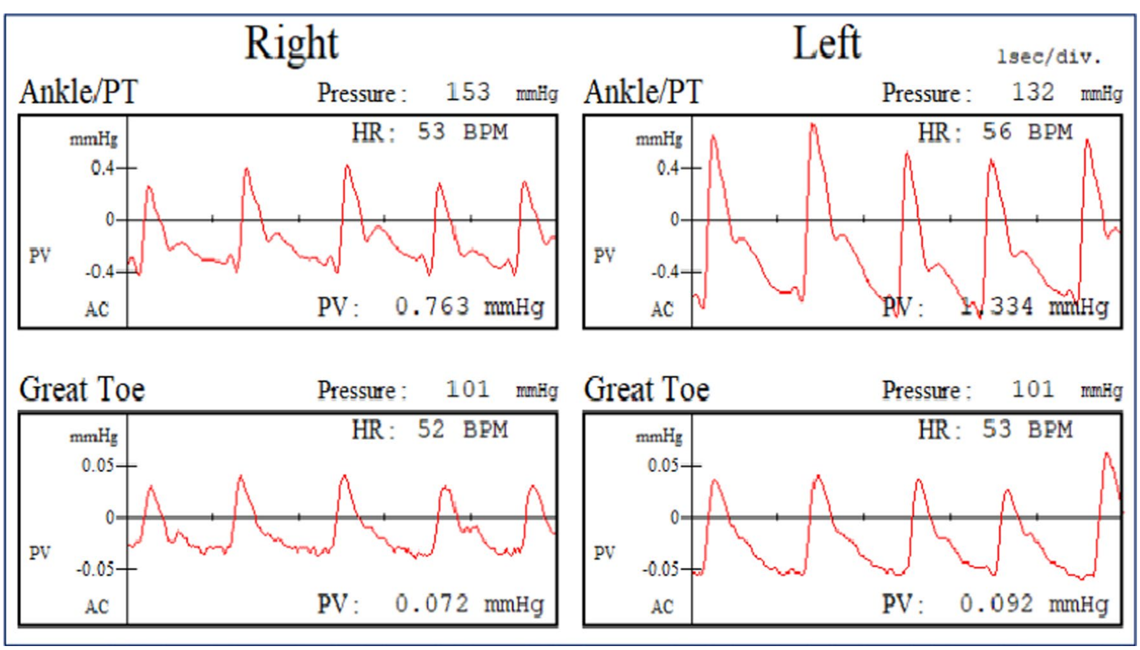

Fig. 4 Waveform from one of the study participants having similar features compared to the standard reference

higher mean ABI values. Interestingly, a larger proportion of males had ABI values below the AHA reference on the left leg. These findings are contrary to the consistent trend reported in several prior studies, which documented higher ABIs in males [4, 5, 34]. The observed lower ABI in males in our study can be explained by their higher brachial systolic BP, a well-established physiological difference between sexes [35]. This elevation in brachial pressure likely reduces the ABI ratio by increasing the denominator in the calculation. The physiological differences in brachial pressure between sexes, driven by factors such as wave reflection and stroke volume, provide a plausible reason for the lower ABI values in males, despite similar central BP across sexes [36]. Despite these variations, a consistent theme across studies is the presence of sex-related differences in peripheral arterial indices, highlighting the complex interplay of factors influencing vascular health. This further underscores the importance of adopting a comprehensive evaluation approach that accounts for sex and other variables when interpreting these indices.

With the rising prevalence of PAD in Sub-Saharan Africa, the current evidence base remains sparse and predominantly facility-based. Most of these studies use internationally established reference values, such as those recommended by the American Heart Association (AHA), and, likely, these criteria are also applied in clinical practice [37]. To evaluate whether these reference criteria are appropriate for assessing peripheral arterial function in younger populations, we evaluated ABI and TBI values based on AHA standards. A significant proportion of participants had indices below these reference values, indicating abnormal peripheral arterial function. However, pulse volume waveform (PVW) analysis, which is comparable to spectral Doppler [38], revealed no abnormalities in those with lower ABI and TBI values. Most participants exhibited triphasic (grade A) waveforms, reflecting good arterial health. This inconsistency—where individuals classified as having PAD based on ABI/TBI showed normal PVWs—raises concerns about the applicability of these reference values in younger populations.

These findings suggest that borderline low ABI and TBI values in young adults may not necessarily indicate abnormal peripheral arterial function. Previous studies have reported similar findings, raising the question of whether the reference values for ABI and TBI, particularly in younger populations, should be reconsidered [18]. For example, AHA guidelines, primarily designed for older populations, might not fully capture the physiological differences in younger individuals, who typically have less arterial hardening and lower vascular risk. As such, applying these adult-focused criteria in younger populations could lead to misclassification and overestimation of PAD in these groups [4]. Pulse volume waveforms (PVWs), often utilized when ABI readings are elevated due to arterial calcification and stiffening—conditions commonly linked to diabetes mellitus—may offer a more suitable alternative for assessing peripheral arterial function in younger adults. Pulse volume recording (PVR) captures PVWs, reflecting real-time vascular dynamics, which can provide a more reliable assessment, particularly in cases where ABI has limitations or may result in misclassification [39–41].

This study has several limitations and strengths that should be acknowledged. First, the thorough recruitment strategy aimed at selecting a homogenous group to maximize internal validity may have reduced the sample size, limiting its generalizability. However, this approach ensured a narrow age range of participants, minimizing confounding factors and providing valuable preliminary insights. Nevertheless, our sample size remains larger than most similar studies conducted in our setting [15], emphasizing the reliability of our findings.

A key strength of this study is the use of an automated oscillometric device, a technique that has been validated for measuring ABI, TBI, and PVWs due to its high accuracy, sensitivity, and specificity compared to the gold standard of Doppler ultrasound [2]. The brand we used, although less validated in the literature compared to others, has been in clinical use for over a decade, particularly in Asia, and is increasingly employed in low- and middle-income countries due to its affordability and practicality [15, 29–31]. By providing simultaneous blood pressure measurements from both arms and ankles, the device minimizes temporal bias and offers a feasible alternative in settings where Doppler ultrasound is not readily available.

Additionally, while we followed the 2012 AHA measurement protocol, we applied the updated 2024 AHA reference values, ensuring that our results align with current standards. Despite trivial discrepancies, the similarity between the 2012 and 2024 protocols minimizes potential methodological differences. Finally, as a pilot study, our findings stimulate further research to address the observed discrepancies and potentially develop population-specific reference values in a setup where such research is still limited.

5 Conclusion and Recommendation

Although young black Africans generally exhibit favorable cardiovascular health, as evidenced by normal pulse volume waveforms (PVWs), our study identified significant discrepancies in ankle-brachial index (ABI) and toe-brachial index (TBI) values when using the current AHA reference standards. Additionally, we observed significant differences between the left and right legs and between sexes in ABI measurements. These findings highlight the complexity of vascular assessments and suggest that standard reference values may not adequately reflect the physiological characteristics of this demographic. Future research should aim to refine vascular health indices for diverse populations and further investigate the underlying causes of these disparities. Such work would enhance preventive health strategies and support the revision of standard references to be more inclusive and representative of varied populations.

Abbreviations

ABI	Ankle-Brachial Index
AHA	American heart association
BMI	Body Mass Index
BP	Blood pressure
HC	Hip circumference
IQR	Inter quantile range
LMIC	Lower- and middle-income countries
MET	Metabolic equivalent
MUHAS	Muhimbili university of health and allied science
PAD	Peripheral arterial disease
PAF	Peripheral arterial function
PPG	Photoplethysmography
PVR	Peripheral volume recording
PVW	Pulse volume waveform
HR	Heart rest
SD	Standard deviation
SPSS V 23	Statistical package for social science version 23
TBI	Toe-Brachial Index
WC	Waist circumference
WHR	Waist-to-hip ratio

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Author Contributions
TEM conceptualized the study, collected and analyzed the data, and authored the manuscript. AE, OM, OC, and JJR contributed to the study's conceptualization and analysis. FM conceptualized and supervised the study, oversaw data collection, and critically reviewed the manuscript. All authors actively participated in the manuscript writing and approved the final version.

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Data Availability
The corresponding author can supply the data used in this work upon reasonable request.

Declarations

Conflict of interest
The authors declare no competing interests.

Ethical Approval and Consent to Participate
Ethical clearance was obtained from the Institutional Review Board of MUHAS. Permission to conduct the study was provided by the MUHAS administration, and participants signed the informed consent form before being enrolled.

Consent for Publication
Not applicable.

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