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Age- and gender-specific reference values of pulse wave velocity for African adults: preliminary results

Pedro Magalhães · Daniel P. Capingana · Amílcar B. T. Silva · Albano V. L. Ferreira · Roberto de Sá Cunha · Sérgio L. Rodrigues · José G. Mill

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Abstract Pulse wave velocity (PWV) is an independent predictor of cardiovascular (CV) risk. Higher PWV values have been observed in Africans; however, there are no established age- and gender-adjusted reference values for this population. Therefore, PWV was measured using a validated device (Complior SP) in 544 subjects recruited from an occupational cohort of employees of a public university in Angola. Since high blood pressure (BP) is an important factor influencing PWV, a subsample of 301 normotensive subjects (aged 22–72 years) was selected for this study. A subset of 131 individuals without CV risk factors was considered the healthy group (HG), while the entire group (n=301) comprised the less healthy group (LHG). Predictors of PWV were evaluated using multiple regression analyses and age- and gender-specific percentile tables and curves were constructed. Age and PWV means were 36±9.7 years and 6.6±1.0 m/s in the HG, respectively, and 39.9±10.2 years and 7.3±1.3 m/s in the LHG. Age and plasma uric acid (UA) were the only significant PWV predictors in the HG, while age, mean BP (MBP), and gender showed significant prediction of PWV in the multiple regression analysis in the LHG. Age- and gender-adjusted reference values of PWV were provided for healthy and less healthy normotensive Africans. Considering the small sample size of our cohort, these preliminary results should be used cautiously until data on robust sample of the general population can be obtained.

Keywords Pulse wave velocity · Reference values · Africans

P. Magalhães · D. P. Capingana · R. de Sá Cunha · S. L. Rodrigues · J. G. Mill
Federal University of Espírito Santo, Vitoria, Brazil

P. Magalhães (✉) · D. P. Capingana · A. B. T. Silva · A. V. L. Ferreira
Department of Physiology, Faculty of Medicine, University Agostinho Neto, Luanda, Angola
e-mail: pedromagalhaes24@hotmail.com

Introduction

The World Health Organization projected the greatest increases in deaths by noncommunicable diseases, primarily cardiovascular (CV), in African countries until the year 2020. However, in 2008, the prevalence of some CV risk factors in African countries, such as hypertension, exceeded those in the Americas (WHO 2010). Arterial stiffness, a condition closely related to hypertension, is an independent predictor of CV risk and all-cause mortality (Laurent et al. 2007; Vlachopoulos et al. 2010), and the carotid–femoral pulse wave velocity (PWV) measurement is the gold standard for arterial stiffness assessment (Laurent et al. 2007). Data from clinical studies has demonstrated the relationship between the levels of PWV and the CV risk in different populations (Safar et al. 2002; van Popele et

al. 2006; Vlachopoulos et al. 2010). Nevertheless, it has been observed that Africans from South Africa (Schutte et al. 2011) and Africans in the Americas (Ferreira et al. 1999; Lemogoum et al. 2006; Heffernan et al. 2007; Santos et al. 2010; Shah et al. 2012) have higher PWV and blood pressure (BP) values than their Caucasian counterparts. Therefore, the measurement of PWV has been recommended for the routine evaluation of aortic stiffness of patients for the assessment of target organ damage in the management of hypertension (Mancia et al. 2007).

However, the use of PWV values in clinical assessment of patients depends on previous definition of cut-off values to ascertain the levels that may increase risk. In this regard, several studies using different methods of measurement defined reference values for specific groups, including Caucasian children and teenagers (Alecu et al. 2008; Boutouyrie and Vermeersch 2010; Reusz et al. 2010). Among these studies, the most comprehensive one culminated with defining reference values of PWV for a European population (Boutouyrie and Vermeersch 2010). In African populations, only one study proposed age-adjusted threshold values of PWV for defining arterial stiffness associated with increased CV risk in a population of young, native South Africans, without a specific analysis by gender (Shiburi et al. 2006). Therefore, studies of PWV characteristics in Africans are still scarce despite of the increasing incidence of CV diseases in this population. Age and gender, however, are two strong predictors of arterial stiffening. A parallel analysis of these two factors is important in view of the well-known influence of gender on the pattern of CV morbidity and mortality (Lerner and Kannel 1986; Anderson et al. 1991; Li et al. 2006; Shaw et al. 2008; Maas and Appelman 2010; Claassen et al. 2012; Yang and Kozloski 2012).

Therefore, the aim of this study was to define reference values for carotid–femoral PWV by age and gender in a sample of normotensive Africans. In a subgroup analysis, these values were also determined by a subsample without CV risk factors.

Methods

Study design and population

This study included only normotensive (Mancia et al. 2007) subjects (n=301, age 22–72 years) without known CV diseases (previous stroke or myocardial infarction), who were selected from a database of a cross-sectional study on CV risk factors in employees of a public university in Luanda, Angola. This study was performed by the Department of Physiology, Faculty of Medicine, Agostinho Neto University (UAN), Angola and all data were collected from February 2009 to December 2010.

Briefly, subjects 20 years and older working at UAN in Luanda were invited to participate of a CV risk factor survey. The eligible population for the study comprised 1,458 staff people, 50.3 % of which were nonteaching staff performing nonmanual or manual activities (Bruin et al. 1996), typical of a superior educational institution. The study goal was to include 50 % (n=729) of the population. However, due to difficulties to include participants living far from the local where the data were collected, the study enrolled 42.2 % (n=615) subjects. PWV was obtained in 544 of these subjects (51 % of which were nonteaching staff) and 301 were considered as normotensive (BP< 140/90 mmHg, without use of antihypertensive drugs). Considering that other CV risk factors beyond BP may affect arterial stiffness, a subset of 131 individuals with normal BP (<130/85 mmHg) without any classical CV risk factor (diabetes, history of alcohol abuse, smoking, obesity, or dyslipidemia) was selected to a separate analysis. This group was referred to as the healthy group (HG), while the entire group (n=301) was referred to as the less healthy group (LHG). The study was conducted according to the tenets of the Declaration of Helsinki, and all subjects signed an informed consent form approved by the ethics committee of the Faculty of Medicine, UAN.

Study protocol and laboratory examinations

Participants attended to the Faculty of Medicine after 12 h of fasting. They were asked to refrained from smoking, physical exercise, and caffeinated beverages for at least 12 h before the visit. Clinical exams were performed between 8 am and noon in a temperature-controlled room (22 °C–23 °C). Venous blood samples were obtained in the forearm by standard techniques and processed immediately using commercially available kits (Biosystems S.A. Costa Brava 30, Barcelona, Spain) for determination of serum triglycerides, total cholesterol, high-density lipoprotein cholesterol (HDL-C), glucose, creatinine, and uric acid (UA).

All biochemical parameters were analyzed by enzymatic methods with a spectrophotometer (Biosystems BTS 310, Barcelona, Spain). Low-density lipoprotein cholesterol (LDL-C) was calculated according Friedewald et al. (1972) and very low density lipoprotein cholesterol (VLDL-C) was calculated as triglycerides/5 in those with triglycerides <400 mg/dL according to the Third Report of the National Cholesterol Education Program Expert Panel on detection, evaluation, and treatment of high blood cholesterol in adults, or NCEP-ATP III. Diabetes mellitus was defined as fasting glucose ≥126 mg/dL or the use of antidiabetic drugs (Pereira et al. 2006). Dyslipidemia was defined according to the NCEP-ATP III criteria if at the least one or more of the following lipid alterations were present: total cholesterol≥200 mg/dL, triglycerides≥150 mg/dL, LDL-C≥160 mg/dL, and HDL-C<40 mg/dL for men or <50 mg/dL for women.

Demographic, anthropometric, and clinical data collection

Each participant answered a questionnaire regarding demographics and medical history, including the use of drugs, diet, and familiar diseases. Smoking was also assessed using an international standardized questionnaire (Tunstall-Pedoe et al. 1994). Participants were classified as nonsmokers (never and ex-smokers) and current smokers (daily and occasional smokers). Alcohol consumption was assessed according to their answer to the question about alcoholic beverage consumption (yes/no). Anthropometric measures included weight and height and waist and hip circumferences obtained in the individuals using underwear clothing. Body mass index (BMI) was calculated as the weight by the square height (kilogram per square meter). According to the BMI values, the participants were classified as normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (≥30.0 kg/m^2) (WHO 1998).

Hemodynamic parameter assessment

The basal BP and heart rate were measured three times in the nondominant arm after 5 min of resting in a sitting position with the arm at the level of heart. These parameters were measured using a validated, automated digital oscillometric sphygmomanometer (Omron 705CP, Tokyo, Japan) with an appropriately sized cuff. The readings were repeated at 3-min intervals. The mean of the last two readings was recorded. The pulse pressure (PP) was computed as difference between basal systolic BP (SBP) and diastolic BP (DBP). Mean BP (MBP) was computed as the DBP+(PP/3). Hypertension was defined as a SBP≥140 mmHg and/or DBP≥90 mmHg and/or the use of antihypertensive drugs. Carotid–femoral PWV was measured noninvasively by an experienced observer who was blinded to other clinical characteristics of participants. A Complior SP® device (Artech Medical, Pantin, France) was used to measure PWV after each participant had rested for 10–15 min in a supine position. Technical characteristics of this device have been described in detail in a previous validation study (Asmar et al. 1995). The carotid artery and femoral artery pressure waveforms were recorded noninvasively by simultaneous assessment of the pulse waves in the right common carotid and femoral arteries as described (Santos et al. 2010). Because the PWV values were obtained based on the direct carotid–femoral distance, the values were then standardized to the 'real' carotid–femoral distance by multiplying by 0.8 according to recent consensus recommendations (Van Bortel et al. 2012).

Definition of groups for reference values

To generate the LHG and HG, we first tested the independent effects of the CV risk factors, including hypertension, diabetes, obesity, smoking, dyslipidemia, and gender, on PWV values in the entire study population (n=544). The results showed that the only factors associated with PWV values were hypertension and gender, even after adjusting for age and MBP. The hypertensive subjects were then eliminated, resulting in the LHG of normotensive subjects with at least one CV risk factor. To attenuate the effect of BP, the HG was composed of individuals with normal BP values (<130/85 mmHg). The effect of gender on PWV was tested in the HG by multivariable regression analysis before and after adjusting for age. The results indicated that the age-adjusted effect of gender on PWV values was not significant (P=0.084); therefore, the proposed reference values for PWV were combined for both genders in this group only.

Statistical analysis

The data analysis was performed using SPSS software, version 13.0 (SPSS Inc., Chicago, IL, USA). The

normality of the data was examined using the Kolmogorov–Smirnov test. In each group, continuous variables are reported as the mean±standard deviation (SD) and compared by gender using the independent samples *t* test. Categorical variables were expressed as proportions and compared using the chi-square test. Univariate correlation was performed to assess the relationship between PWV and other covariates. A multiple linear regression analysis was performed to determine the independent influence of risk factors on PWV. This analysis was also performed to precisely exclude relevant risk factors that influence the PWV, prior to establishing the reference values.

The reference values of PWV were then presented as the means±SD and the percentiles per age decade by gender (<30, 30–39, 40–49, and ≥50 years) for the LHG and (<30, 30–39, and ≥40 years) for the HG. The respective percentile curves were also constructed. A $P<0.05$ was considered statistically significant for all tests.

Results

Characterization of study groups

The characteristics of the two groups by gender are presented in the Table 1. The LHG comprised subjects with a mean age of 39.9±10.2 years (22–72 years) and the HG with age of 36±9.7 years (22–70 years). In the LHG, men had higher values for height, SBP, PP, PWV, glucose, waist-to-hip ratio (WHR), creatinine, and UA. Conversely, the women had higher BMI, waist and hip circumferences, heart rate, total cholesterol, LDL-C and HDL-C, obesity, hypercholesterolemia, and lower HDL-C. Moreover, there was no significant difference for other characteristics between men and women.

In the HG, 51.1 % of this group were women (Table 1), and men had higher age, height, WHR, creatinine, UA, SBP, PP, and PWV values. The women had higher values for BMI, heart rate, HDL-C, and hip circumference. However, there were no differences in the values for waist circumference, DBP, MBP, glucose, triglycerides, total cholesterol, and LDL-C.

Relationship between PWV and relevant covariates in the two groups

In the HG, PWV was correlated with age ($r=0.54$, $P<0.001$), WHR ($r=0.20$, $P=0.022$), UA ($r=0.20$, $P=0.023$), and SBP ($r=0.18$, $P=0.045$). In the LHG, univariate regression analysis showed a positive correlation between PWV and age ($r=0.49$, $P<0.001$), SBP ($r=0.41$, $P<0.001$), MBP ($r=0.39$, $P<0.001$), WHR ($r=0.21$, $P<0.001$), UA ($r=0.21$, $P<0.001$), creatinine ($r=0.19$, $P=0.001$), and glucose ($r=0.12$, $P=0.042$).

By multiple regression analysis, which included as independent variables the age, WHR, UA, and SBP for the HG and the age, MBP, gender, WHR, UA, and glucose for the LHG, age and UA were the only independent predictors of the PWV, accounting for 31 % variability in the HG, while age, MBP, and gender emerged as independent predictors of the PWV explaining 34.4 % of variability in the LHG (Table 2). In both groups, PWV increased with aging. Scatter plots showing the linear regression between age and PWV and the 95 % prediction band for values of PWV in the LHG, separated by gender, are shown in Fig. 1a and a scatter plot with the genders combined in the HG in Fig. 1b.

Reference values of PWV

From each group, we calculated the percentiles of PWV. For the LHG, values were plotted by age and separated by gender as presented in Table 3 and the percentile curves (Fig. 2). As expected, for the same age group, men had higher values than women in the upper limit (95th percentile). This difference was observed primarily over the age of 30 years, and the mean difference ranged from 1.0 to 1.6 m/s, indicating a pronounced gender modulation of age-related PWV increases. Percentile values of PWV calculated for the HG were combined for men and women and are presented in Table 4.

Discussion

In this study, we defined reference values of PWV for healthy and less healthy normotensive African cohort. The extension of these data to the general African population, however, should be viewed cautiously because the sample is only representative of professional cohort and the number of individuals, mainly those without CV risk factor, is quite limited to establish reference values extensive to the general population. Validation of this study, however, stems from

Table 1 Characteristics of groups according to gender

Characteristic	Less healthy group (n=301)			Healthy group (n=131)		
	Men	Women	P value	Men	Women	P value
N	147	154		64	67	
Age (years)	40.8±10.8	39.1±9.5	0.167	37.9±11	34.2±7.9	0.03
Weight (kg)	63.9±13	64.9±13.1	0.495	63.0±10.8	61.9±10.2	0.547
Height (cm)	167.7±7.5	160.5±7.2	<0.001	167.9±7.5	162.0±6.5	<0.001
BMI (kg/m^2)	22.6±3.6	25.1±4.6	<0.001	22.3±2.8	23.5±3.4	0.021
WC (cm)	75.0±10.9	79.3±12.1	0.001	73.8±9.6	74.6±9.6	0.668
HC (cm)	89.0±9.0	96.6±10.1	<0.001	87.9±7.8	94.6±8.1	<0.001
WHR	0.84±0.08	0.82±0.09	0.017	0.84±0.09	0.79±0.07	<0.001
SBP (mmHg)	120.6±9.7	115.6±11.5	<0.001	116.7±7.7	111.6±8.9	0.001
DBP (mmHg)	73.0±7.5	73.0±7.6	0.731	69.8±6.8	70.7±6.4	0.437
PP (mmHg)	47.6±6.8	42.3±7.3	<0.001	46.9±7.3	41.0±5.2	<0.001
MBP (mmHg)	88.8±7.7	87.4±8.4	0.114	85.4±6.2	84.3±6.9	0.35
Heart rate (bpm)	65±9	69±9	<0.001	64±10	69±9	0.001
PWV (m/s)	7.3±1.4	6.7±1.1	<0.001	6.8±1.0	6.3±0.9	0.008
Glucose (mg/dL)	94.3±22.6	88.7±13.8	0.01	89.7±13.0	87.5±11.2	0.289
Creatinine (mg/dL)	1.13±0.20	0.97±0.17	<0.001	1.11±0.20	0.98±0.15	<0.001
Uric acid (mg/dL)	6.0±1.6	4.5±1.3	<0.001	6.0±1.8	4.2±1.1	<0.001
TC (mg/dL)	178.9±36.0	189.5±34.4	0.009	160.5±27.0	168.6±23.1	0.069
LDL-C (mg/dL)	114.6±36.1	123.5±35.5	0.032	97.9±26.4	104.0±25.1	0.177
HDL-C (mg/dL)	44.9±10.9	48.1±11.3	0.014	51.1±8.9	59.0±8.3	<0.001
TGL (mg/dL)	96.7±40.5	89.6±34.0	0.098	80.6±28.7	78.8±24.4	0.71
Risk factors						
Obesity	4 (2.7)	25 (16.2)	<0.001	–	–	–
Diabetes	6 (4.1)	5 (3.2)	0.7	–	–	–
Current smoking	13 (8.3)	6 (3.9)	0.078	–	–	–
Alcohol drinking	85 (57.8)	85 (55.2)	0.646	–	–	–
High TC	38 (25.9)	56 (36.4)	0.049	–	–	–
High TGL	16 (10.9)	10 (6.5)	0.175	–	–	–
High LDL-C	22 (15.0)	29 (18.8)	0.372	–	–	–
Low HDL-C	52 (35.4)	90 (58.4)	<0.001	–	–	–

Values are the means±SD or percentages. In each group, values were compared between men and women by the independent t test, and risk factors were compared by chi-square test (only in the less healthy group)

BMI body mass index, *WC* waist circumference, *HC* hip circumference, *WHR* waist-to-hip ratio, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *PP* pulse pressure, *MBP* mean blood pressure, *PWV* pulse wave velocity, *HDL-C* high-density lipoprotein cholesterol, *LDL-C* low-density lipoprotein cholesterol, *TC* total cholesterol, *TGL* triglycerides

scarcity of such data for African populations. In our study, the PWV was measured using gold standard methods under standardized conditions (Laurent et al. 2007). Because we used the direct carotid–femoral distance to obtain the PWV measures, the values were standardized for pulse traveling distance as is recommended (Van Bortel et al. 2012). Our results establish reference values for less healthy adult men and women separately, whereas in healthy people, we defined the same values for men and women. The effect of gender on reference values has been analyzed for Caucasian (Alecu et al. 2008; Boutouyrie and

Table 2 Multiple linear regression models for PWV values in the two groups

	Unstandardized coefficient $\beta \pm SE$	*P* value	Adjusted R^2
Healthy			
Model 1			0.289
Constant	5.784±0.340	<0.001	
Age	0.067±0.009	<0.001	
Model 2			**0.308**
Constant	5.288±0.409	<0.001	
Age	0.066±0.009	<0.001	
Uric acid	0.109±0.051	0.036	
Less healthy			
Model 1			0.238
Constant	5.683±0.326	<0.001	
Age	0.077±0.008	<0.001	
Model 2			0.322
Constant	0.862±0.841	0.306	
Age	0.067±0.008	<0.001	
MBP	0.059±0.010	<0.001	
Model 3			**0.344**
Constant	1.899±0.883	0.032	
Age	0.065±0.008	<0.001	
MBP	0.057±0.010	0.002	
Gender (2= female)	−0.504±0.150	0.001	

Bold was used only to distinguish the adjusted R^2 values in the final regression models

SE standard error, *MBP* mean blood pressure

Vermeersch 2010; Reusz et al. 2010) but not for African (Shiburi et al. 2006) populations. In two of these studies, values were defined separated by gender, (Alecu et al. 2008; Reusz et al. 2010) but not in the other one because they found a small effect of gender on PWV values (Boutouyrie and Vermeersch 2010). However, this adjustment is needed for practical use considering the gender-related pattern of CV morbidity and mortality (Lerner and Kannel 1986; Anderson et al. 1991; Li et al. 2006; Shaw et al. 2008; Maas and Appelman 2010; Claassen et al. 2012; Yang and Kozloski 2012).

The importance of routine measurements of PWV was reiterated in the most recent expert consensus on aortic stiffness measurement (Van Bortel et al. 2012). Despite the recognized value of PWV for predicting CV risk, there is an absence of reference values for all populations. Investigators have established values for normality or reference values for specific groups, particularly for Caucasian populations (Alecu et al. 2008; Boutouyrie and Vermeersch 2010; Reusz et al. 2010), with insufficient data for African populations. To date, only one study defined the age-specific threshold values for PWV measured using a SphygmoCor device (AtCor, Sydney, Australia) in 159 young Africans from South Africa (mean age 33.5 years) without hypertension or diabetes (Shiburi et al. 2006). Although they did not adjust for gender, they suggested that at an age of 30 years, values of PWV exceeding 8 m/s should indicate an excessive age-related arterial stiffness increase. This value would be adjusted by a 1 m/s increase for each decade over the age of 30 years. In this study, we defined values of PWV for two groups, and our calculated values (95th percentile) at age of 30 years (both sexes combined) are 8.4 m/s and 8 m/s in LHG and HG, respectively. However, our results do not allow us to make a direct comparison because we converted values of PWV to standardize for traveling distance (Van Bortel et al. 2012).

Recently, normal and reference values were published for a European population, which were standardized for pulse traveling distance (Boutouyrie and Vermeersch 2010). They defined two groups of population: 'normal' (normotensives without CV risk factors) and 'reference' (high normal BP, hypertensives, and other risk factors except, diabetes and that on treatment for dyslipidemia and/or hypertension). However, unlike our study, they did not find a significant effect of gender on PWV in the two groups. Although we are unable to make an extensive comparison in all age groups because of our small sample size, the values of mean and median (10th and 90th percentiles) established for our HG (Table 3) are consistent with the proposed values for a normal Europeans population, aged <30 and 30–39 years [mean: 6.2; median: 6 (5–7.3)m/s and mean: 6.5; median: 6.4 (5.2–8.0)m/s, respectively] (Boutouyrie and Vermeersch 2010). This suggests that ethnic differences in age-related arterial stiffening are apparent only in older populations with risk factors. However, our data do not allow us to compare older individuals, in which we believe there are ethnic differences based on the fact that there are more risk factors in the African population compared to Caucasian Europeans.

In this study, reference values were established in two different groups of Africans from Angola. They were tested for which factors importantly influenced

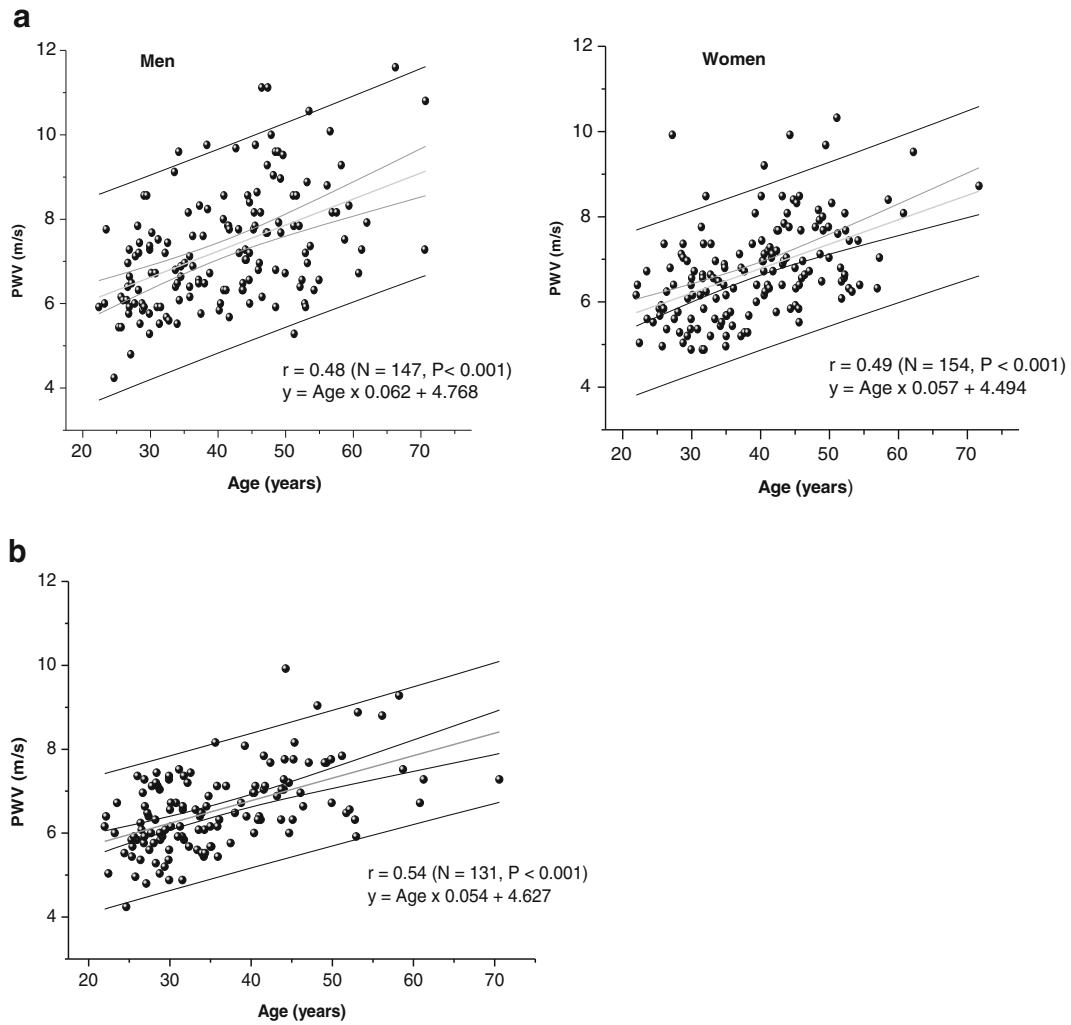

Fig. 1 Association of PWV with age in the less healthy (**a**) and healthy (**b**) groups. The *central line* in each panel shows the predicted line and its confidence intervals based on linear regression results of age in relation to PWV. *Upper and lower lines* are the 95 % and 5 % prediction bands, respectively, for acceptable values. The figure shows the scatter plot of values of PWV. For the less healthy group, certain outlying values can be observed outside the 95 % prediction band

PWV variability and enabled us to define the HG and LHG. The results showed that, in addition to age, hypertension influenced PWV the most and statistically overshadowed the effects of other risk factors. This finding is consistent with the knowledge that the age-related PWV change is highly influenced by BP levels (Boutouyrie and Vermeersch 2010). On the other hand, this corroborates with previous studies suggesting that arterial stiffness increases were the most pressure-related in Africans and age-related in Caucasians (Ferreira et al. 1999; Schutte et al. 2011). Notably, by multivariable analysis, we found that gender affected PWV only in the group of subjects with CV risk or the LHG. This effect was not seen in the HG. Consequently, reference values were defined by gender for the LHG.

Although a modifying effect of gender on CV morbidity and mortality is known, with regard to the gender modulation of age-related aortic stiffening, the data reported in the literature is still controversial. Most studies have not found any difference in age-related aortic stiffening between men and women (Heijden-Spek et al. 2000;

Table 3 Percentiles of PWV in the less healthy group according to age and gender

Age (years)	Gender	Number of subjects	*M*±SD	Percentiles						
				5	10	25	50	75	90	95
<30	Men	33	6.4±1.0	4.6	5.3	5.8	6.1	7.2	7.8	8.6
	Women	31	6.1±1.0	4.9	5.0	5.4	5.8	6.7	7.3	8.4
	Combined	64	6.3±1.0	4.9	5.1	5.6	6.0	7.0	7.4	8.4
30–39	Men	36	7.0±1.1	5.5	5.7	6.2	6.7	7.6	8.6	9.6
	Women	47	6.2±0.8	4.9	5.2	5.5	6.2	6.7	7.4	8.0
	Combined	83	6.6±1.0	5.2	5.3	5.8	6.5	7.0	8.0	8.4
40–49	Men	49	7.8±1.4	5.9	6.0	6.6	7.8	8.6	9.7	10.6
	Women	55	7.2±0.9	5.8	6.1	6.6	7.1	7.8	8.5	9.3
	Combined	104	7.5±1.2	5.8	6.1	6.6	7.2	8.1	9.4	9.7
≥50	Men	29	7.9±1.5	5.6	6.0	6.6	7.8	8.7	10.6	11.2
	Women	21	7.4±1.2	6.1	6.3	6.4	7.4	8.2	9.4	10.2
	Combined	50	7.7±1.4	6.0	6.2	6.6	7.5	8.4	10.0	10.7
Total	Men	147	7.3±1.4	5.5	5.8	6.3	7.1	8.2	9.3	9.9
	Women	154	6.7±1.1	5.2	5.4	5.9	6.6	7.4	8.2	8.5
All		301	7.0±1.3	5.3	5.5	6.1	6.8	7.8	8.6	9.6

PWV pulse wave velocity, *M*±SD mean and standard deviation

Smulyan et al. 2001); however, other studies have suggested a pronounced age-related increase in aortic stiffness in women more than men, mainly during menopause (Waddell et al. 2001; Vermeersch et al. 2008). These discordant findings have been ascribed to an intrinsic difference in arterial properties between men and women, possibly influenced by sex steroids (Waddell et al. 2001; Rossi et al. 2011), which may be emphasized in the presence of high BP (Boutouyrie and Vermeersch 2010) or other CV risks such as obesity and diabetes (Rossi et al. 2011). Our results were adjusted for the classic CV risk factors by a forward stepwise multiple regression analysis; however, gender remained correlated with PWV only in normotensive subjects with other risk factors. Although subjects in both groups were normotensives, the different associations with gender in these two groups may be explained by high levels of BP in the presence of other CV risk factors in the LHG, which possibly emphasized gender-specific differences, given that by multiple regression BP remained associated with PWV only in the LHG.

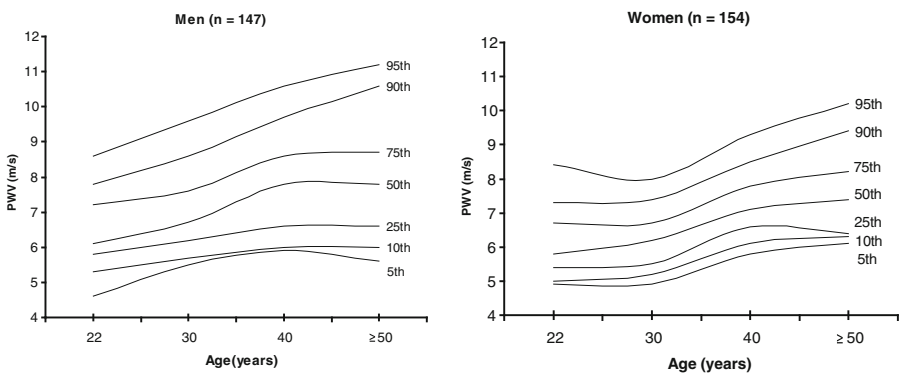

Fig. 2 Percentile curves for carotid–femoral PWV according to age in the less healthy normotensive men and women

Table 4 Percentiles of PWV in the healthy group according to age

Age (years)	Number of subjects	*M*±DP	Percentiles						
			5	10	25	50	75	90	95
<30	47	6.1±0.8	4.8	5.0	5.5	6.0	6.6	7.3	7.4
30–39	41	6.4±0.7	5.4	5.5	5.8	6.4	6.7	7.4	8.0
≥40	43	7.3±0.9	6.0	6.3	6.6	7.1	7.8	8.8	9.2
All	131	6.6±1.0	5.0	5.4	5.9	6.5	7.1	7.7	8.2

PWV pulse wave velocity, *M*±SD mean and standard deviation

Conversely, in the HG, both age and UA were independent predictors of PWV but gender was not associated. Although UA levels have been associated with metabolic syndrome components, low levels of UA have been reported in Africans of both genders (Conen et al. 2004), with men having higher levels of UA than women (Fang and Alderman 2000). Data of a study comparing healthy men from South Africa (age 40 years; Caucasians, $n=121$; Africans, $n=87$), Palmer et al. (2010) found that despite the lower levels of UA in Africans, there was a strong correlation of UA with triglycerides and waist circumference in both ethnic groups, by multiple regression. Curiously, in an additional analysis, they found an association between UA and total peripheral resistance in Africans only. Therefore, these investigators assumed that this relationship would explain the link between UA levels and a higher prevalence of hypertension in African men. Although we did not measure the total peripheral resistance in this study, this rationale is likely to be applicable to our healthy participants because the men in this group had higher mean UA and SBP values compared to women (Table 1). This result suggests a tendency toward an accelerated increase in PWV in young men when other risk factors are present.

There are potential limitations to our study. First, our study population represented the staff of a public university but did not include people who worked at other locations or people who were unemployed. However, our study group included all occupational and socioeconomic classes, including teachers and nonteaching workers. Second, the small sample size limited extensive age categorization because there were few subjects aged 60 years and older. However, this was expected because 48 % of the population in this country is under 15 years old (INE 2011), which is associated with higher mortality in people less than 60 years old and characterizes the majority of the countries in Sub-Saharan Africa (WHO 2010). Third, this study is cross-sectional in design and does not allow causality to be established when examining the relationship between multiple covariates for age-related increases in PWV. Among several factors, we did not have information on HIV status infection of our participants, so were unable to assess the possibility of a confounding effect on the observed values of PWV, given that prior evidence suggests that patients infected with HIV may have increased vascular stiffness, independently of the classical CV risk factors (Schillaci et al. 2008; Seaberg et al. 2010). Finally, the number of individuals without classical CV risk factors is limited to establish reference points to an entire population. However, studies in African populations living in Africa are scarce in this area. To date, only one study was developed in this subject (Shiburi et al. 2006). BP in our cohort, however, was less than in this previous study. This difference is important because BP exerts a strong influence on PWV values (Boutouyrie and Vermeersch 2010). However, considering these limitations, the results of the present study should be confirmed in larger samples of the general population.

In conclusion, this study provided preliminary reference values of carotid–femoral PWV that are age- and gender-specific for normotensive Africans with and without CV risk factors. These data add to the sparse body of knowledge on reference values for PWV in this population. The results also have implications for suitable risk stratification, and consequently, for preventative orientation for early arterial aging in unhealthy or apparently healthy people with higher values of PWV by age and gender.

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