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Research Article

Global Longitudinal Strain and Echocardiographic Parameters of Left Ventricular Geometry and Systolic Function in Healthy Adult Angolans: Effect of Age and Gender. A Pilot Study

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Abstract

Introduction: Studies on the normal echocardiographic reference values in Africans are limited.

Objectives: This study aims to establish the normal left ventricular echocardiographic parameters for adult Angolans, stratified by gender and age.

Methods: A cross-sectional study was performed involving healthy adults attending a diagnostic center in Luanda, Angola. The two-dimensional transthoracic echocardiography was performed according to the Guidelines of the American Society of Echocardiography and the European Association of Cardiovascular Imaging.

Results: A total of 103 men (47.5%) (mean age: 39,5 ± 10,8) and 114 women (52,5%) (mean age: 43,0 ± 12,5 years) were included. Compared to men, women were older (p = 0,025) and showed significantly smaller body surface area (BSA) (p < 0,001). Left ventricular wall thickness, left ventricular end-diastolic dimension and volume (LVEDV), left ventricular mass (LVM) and LVM indexed to BSA (LVMi) were significantly lower in women (p < 0.005). While LVEDD indexed to BSA and left ventricular ejection fraction (LVEF) was significantly higher in women compared to men (p = 0,007), (p = 0,01), respectively. Mitral annular plane systolic excursion, LVEF by strain, and the global longitudinal strain showed no gender differences. Posterior wall thickness showed a statistically significant increase in the older groups (p = 0,043). While VST, relative wall thickness, LVM, and LVMi showed no significant differences between the age categories. In turn, the shortening fraction and the ejection fraction increase with age.

Conclusion: For a more sensitive morphological and functional assessment of the left ventricle, it is necessary to take into account the gender and age of the individual.

Keywords: *Two-dimensional Echocardiography; Global Longitudinal Strain; Speckle tracking; Systolic Function*

Introduction

Echocardiography is the imaging method most often used to assess the anatomy and cardiac function worldwide. Many studies have drawn attention to the influence of age, gender, race/ethnicity/nationality on echocardiographic parameters in healthy populations [1-5].

Several authors even question whether the parameters referred to in the ASE and ESC guidelines should serve as reference values for all populations since they are derived from studies conducted on Americans and Europeans. Some researchers suggest that studies should be carried out to find the reference echocardiographic values for their population. [3,6,7]. With increased awareness of the importance of accounting for age, gender, and ethnicity, several studies have obtained normal reference ranges for echocardiography and Doppler data for specific healthy populations [8].

Moreover, in a study published in 2019, by Ash., *et al*. and carried out in 15 countries that included 2008 healthy individuals, using the same methodology in all centers. The authors concluded that the dimensions and volumes of the left ventricle (LV) are larger in men, while the ejection fraction and the values of the global longitudinal strain (GLS) are higher in women. Inter-country variability is significant for left ventricular volumes, and therefore nationality should be considered for defining ranges of normality [9].

The present study is the second part of a pilot study on echocardiographic values of left ventricular (LV) systolic and diastolic function in healthy adult Angolans. The first part focused on the LV diastolic function and was previously published [10]. This second part aims to evaluate the left ventricular end-diastolic dimensions and volumes, LV systolic function, and left ventricular global longitudinal strain (GLS) by transthoracic echocardiography, in healthy adults Angolan. In addition, the effects of aging and gender on these parameters are also evaluated.

Materials and Methods

The methodology has already been exhaustively described elsewhere [10]. Briefly, a cross-sectional descriptive observational study was carried out in a single diagnostic center in Luanda, Angola. We recruited individuals sent to our echocardiography laboratory. The study included 217 healthy individuals aged 18 years or older who fulfilled the inclusion criteria and agreed to participate in the study. The age, sex, weight, height, and both, the presence or absence of cardiovascular risk factors (CVRF) were recorded on the day when the patients underwent echocardiography. The body surface area (BSA) was calculated by the formula BSA = 0.007184x[(height (cm)]$^{0.725x}$[(weight (kg)]$^{0.425}$ and body mass index (BMI) was calculated by the formula BMI = weight (kg)/height^2 (cm). Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by a specialized healthcare professional minutes before the echocardiographic examination using an aneroid sphygmomanometer, according to the Korotkoff method (k1 to k5 sounds, respectively).

Two-dimensional transthoracic echocardiography

Echocardiography was performed using the commercially available equipment (Mindray DC-70 exp Diagnostic Ultrasound System, with a P4-2 transducer). Two-dimensional transthoracic echocardiography (TTE) was performed and analyzed according to the Guidelines of the American Society of Echocardiography and the European Association of Cardiovascular Imaging [11] by a single experienced and accredited echocardiographer.

The ventricular septal thickness (VST), the posterior wall thickness (PWT), and the diastolic diameter of the left ventricular (LVDD) were measured in the end-diastole; the left ventricle systolic diameter (LVSD) on the end-systole. All of these measurements were made in M-mode, guided by two-dimensional echocardiography. LVM was calculated by the formula: LVM = 0.8 x {1.04 [(LVEDD + PWT+IVT) 3 - (LVEDD) 3]) + 0.6 [10]. The LVM index (LVMI) was calculated by the formula LVMI = LVM/BSA [10]. RWT was calculated according to the following formula: RWT = 2xPWT/LVEDD [10]. Left ventricular shortening fraction (LVSF) was calculated according to the following formula: LVEDD-LVESD/LVEDD*100. Left ventricular ejection fraction (LVEF) was calculated by the Simpson method. The left ventricular systolic function was classified as preserved if LVEF ≥ 55% [11].

Global left ventricular longitudinal strain

For evaluation of global longitudinal strain (GLS) parameters of the left ventricle high-quality images of the long axis, four-chamber, and two-chamber view was acquired. GLS values were obtained according to the previously reported methodology [12].

Inclusion and exclusion criteria

The study included healthy individuals aged 18 years or older who did not have exclusion criteria and agreed to participate in the study. A questionnaire was given to individuals about possible known diseases (cardiac and non-cardiac). Individuals with any chronic condition or chronic medication were excluded. Pregnant women, high competition athletes, and individuals with heavy alcoholic habits were excluded. Arterial hypertension was ruled out based on the measurement taken before the exam: individuals with SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg, and individuals with BMI ≥ 40 kg/m^2 were excluded. Individuals with abnormal values of cholesterol, triglyceride, creatinine, or glucose found in their medical records in the last 6 months were also excluded. Left ventricular ejection fraction mild) valvular heart disease or pericardial disease were also exclusion criteria

Statistical analysis: The data were analyzed according to gender and age group stratification. The normality of distribution was analyzed with the Shapiro-Wilk test, in samples with a size less than 30. In samples with a size greater than 30, the normality of distribution of values was accepted according to the central limit theorem. Qualitative variables were expressed by absolute and relative frequencies and quantitative variables with means and standard deviations. Statistical significance was set to < .05. Independent-samples T test, Anova One-Way, Independent Chi-Square, were used. The low and upper normal limits of the conventional echocardiographic parameters were established as the mean ± 2SD measurement. The data were analyzed using SPSS 27.0 for Windows.

Results

A total of 103 men (47.5%) and 114 women (52,5%) (mean age: 41,3 ± 18,1 years) were included. There were no significant gender differences in BMI, SBP, and DBP. However, women were older (43 years versus 39 years, p = 0,025) and showed significantly smaller BSA (1,8 versus 1,9; p < 0,001) compared to men.

Table 1 shows the echocardiographic parameters of left ventricular geometry and systolic function in the entire population and according to gender. Compared to women, men had łarger left ventricular dimensions (48,1 vs 45,8, p < 0,001) and volumes (101,0 vs 91,7, p < 0,001), had higher VST (9,6 vs 9,0 p < 0,001), higher PWT (9,5 vs 8,6; p < 0,001) and LVM (162,1 vs 133,9; p < 0,001). When LVM is indexed for BSA or height it remains statistically higher in men when compared to women.

	Total (217)	Male (103)	Female (114)	p Value
	Mean ± SD	Mean ± SD	Mean ± SD	
VST (mm)	9.3 ± 1.4	9.6 ± 1.3	9.0 ± 1.5	0.001***
PWT (mm)	9.0 ± 1.4	9.5 ± 1.2	8.6 ± 1.4	0.001***
LVEDD (mm)	46.9 ± 4.7	48.1 ± 4.4	45.8 ± 4.7	0.001***
LVEDD/BSA (mm/m^2)	25.6 ± 2.8	25.1 ± 2.5	26.1 ± 3.1	0.007**
LVEDV (ml)	96.1 ± 21.2	101.0 ± 23.2	91.7 ± 18.3	0.001***
LVEDVBSA (ml/m^2)	52.2 ± 10.6	52.4 ± 11.2	52.1 ± 10.1	0.832
RWT	0.39 ± 0.07	0.38 ± 0.07	0.40 ± 0.06	0.020*
LVM (g)	147.3 ± 39.5	162.1 ± 35.2	133.9 ± 38.5	0.001***
LVM/BSA (g/m^2)	80.0 ± 20.0	84.3 ± 17.4	76.0 ± 21.5	0.002*
LVM/height (g/m)	86.9 ± 22.6	92.8 ± 19.9	81.6 ± 23.7	.001***
LVSF (%)	40.1 ± 7.5	39.2 ± 7.1	40.8 ± 7.7	0.115
LVEF (%)	69.6 ± 8.2	68.2 ± 8.4	71.0 ± 7.7	0.010**
MAPSE (mm)	15.0 ± 2.7	15.1 ± 2.7	15.0 ± 2.6	0.841
FEVE/Strain (%)	52.3 ± 5.6	52.2 ± 5.8	52.3 ± 5.4	0.910
GLS (%)	-18.3 ± 2.8	-18.0 ± 2.7	-18.5 ± 2.9	0.226

Table 1: *Echocardiography parameters in the entire population and according to gender.*
*BSA: Body Surface Area; GLS: Global Longitudinal Strain; LVEDD: Left Ventricular End-Diastolic Diameter LVEDV: Left Ventricular End-Diastolic Volume; LVEF: Left Ventricular Ejection Fraction; LVM: Left Ventricular Masse; LVSF: Left Ventricular Shortening Fraction; MAPSE: Mitral Annular Plane Systolic Excursion; PWT: Posterior Wall Thickness; RWT: Relative Wall Thickness; SD: Standard Deviation; VST: Ventricular Wall Thickness. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ .001.*

Regarding the parameters of systolic function quantification, only LVEF was statistically different between genders showing a higher value in women when compared to men (71% versus 68%; p = 0,01). Women also had greater LVSF (41% versus 39%, p = 0.115). The remaining parameters, such as mitral annular plane systolic excursion (MAPSE), LVEF by strain, and GLS, showed no differences between the gender.

Table 2 summarizes the demographic data in the entire population and according to age categories. Compared to individuals younger than 30 years old, all remainders four age categories had significantly higher SBP and DBP. Patients older than 49 years had also higher BMI than patients younger than 30 years old. Patients in the 50 - 59 age category had lower DBP than patients older than 59 years.

	Total (217)	18-29 (36)	30-39 (71)	40-49 (53)	50-59 (40)	≥ 60 (17)	P Value.
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
M/F(%)	47.5/52.5	55.6 ± /44.4	56.3/43.7	39.6/60.4	16/24	35.3/64.7	0.171
BSA (m^2)	1.8 ± 0.2	1.8 ± .1a	1.9 ± 0.2 b	1.9 ± 0.2	1.8 ± 0.2	1.8 ± 0.1	0.004**
BMI (Kg/m^2)	25.8 ± 4.2	23.6 ± 3.7a	26.1 ± 4.4	26.2 ± 4.1	26.7 ± 4.1b	26.6 ± 3.5b	0.008**
SBP (mmHg)	126.5 ± 9.7	118.1 ± 12.9a	127.0 ± 8.1b	127.0 ± 8.3b	130.0 ± 7.3b	132.2 ± 5.8b	0.001***
DBP (mmHg)	73.5 ± 8.3	68.1 ± 8.5a	73.7 ± 7.7b	73.6 ± 7.8b	75.2 ± 7.9bc	79.5 ± 6.7c	0.001***

Table 2: *Baseline clinical characteristics in the entire population and according to age categories.*
*BSA: Body Surface Area; BMI: Body Mass Index; DBP: Diastolic Blood Pressure; F: Female; M: Male; SD: Standard Deviation; SBP: Systolic Blood Pressure. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001. There is a significant statistically difference between the groups with the letters a and b; a and c; b and c.*

Table 3 shows parameters of the left ventricular geometry and systolic function in the entire population and according to age categories. Regarding the morphological parameters, the values of the PWT showed a statistically significant increase in the older groups (p = 0,043). Although there is an increase in IVS, in RWT, LVM and LVM indexed to BSA and height with increasing age, none of these parameters demonstrated a significant difference between the various age groups.

	Total	18-29 (36)	30-39 (71)	40-49 (53)	50-59 (40)	≥ 60 (17)	p Value
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
VST (mm)	9.3 ± 1.4	9.1 ± 1.4	8.9 ± 1.4	9.5 ± 1.2	9.6 ± 1.7	9.7 ± 1.3	0.056
PWT (mm)	9.0 ± 1.4	8.6 ± 1.3a	8.9 ± 1.5	9.0 ± 1.2	9.4 ± 1.4	9.5 ± 1.3b	0.043*
LVEDD (mm)	46.94.7	46.2 ± 3.8	47.5 ± 4.9	46.5 ± 5.3	46.9 ± 4.8	47.3 ± 3.8	0.630
LVEDD/BSA (mm/m^2)	25.6 ± 2.8	26.3 ± 2.1	25.3 ± 2.6	25.2 ± 3.0	25.6 ± 3.4	26.8 ± 3.3	0.139
LVEDV (ml)	96.1 ± 21.2	90.3 ± 20.0	99.7 ± 23.7	98.4 ± 19.8	91.6 ± 17.9	96.8 ± 21.8	0.125
LVEDV/BSA (ml/m^2)	52.2 ± 10.6	51.2 ± 10.1	52.8 ± 11.2	53.2 ± 9.3	50.0 ± 10.4	54.7 ± 13.0	0.449
RWT	0.39 ± 0.07	0.37 ± 0.05	0.38 ± 0.07	0.39 ± 0.07	0.41 ± 0.07	0.41 ± 0.07	0.109
LVM (g)	147 ± 39	137 ± 35	145 ± 39	147 ± 39	155 ± 46	158 ± 31	0.235
LVM/BSA (g/m^2)	80.0 ± 20.0	77.6 ± 17.2	76.8 ± 18.6	79.2 ± 17.2	84.6 ± 25.9	89.9 ± 20.6	0.069
LVM/height (g/m)	86.9 ± 22.6	81.2 ± 19.9	84.3 ± 21.1	87.0 ± 21.8	92.7 ± 28.3	96.1 ± 18.2	0.071
LVSF (%)	40.1 ± 7.5	37.5 ± 6.0 a	39.5 ± 7.6 a	40.7 ± 6.9 a	40.4 ± 6.9	45.3 ± 10.0 b	0.008**
LVEF (%)	69.6 ± 8.2	68.1 ± 7.9 a	68.0 ± 8.8 a	70.6 ± 7.7	70.8 ± 6.8	74.2 ± 8.9 b	0.024*
MAPSE (mm)	15.0 ± 2.7	15.1 ± 2.5	15.1 ± 2.4	15.1 ± 2.4	14.6 ± 3.1	15.5 ± 3.6	0.829
LVEF/Strain (%)	52.3 ± 5.6	54.0 ± 5.6	52.0 ± 6.2	52.0 ± 4.5	51.3 ± 5.9	53.0 ± 5.0	0.275
GLS (%)	-18.3 ± -2.8	-18.8 ± -2.2	-18.4 ± -3.0	-18.1 ± -2.6	-17.8 ± -3.2	-18.6 ± -2.8	0.534

Table 3: *Echocardiographic parameters in the entire population and according to age.*
*BSA: Body Surface Area; GLS: Global Longitudinal Strain; LVEDD: Left Ventricular End-Diastolic Diameter LVEDV: Left Ventricular End-Diastolic Volume; LVEF: Left Ventricular Ejection Fraction; LVM: Left Ventricular Masse; LVSF: Left Ventricular Shortening Fraction; MAPSE: Mitral Annular Plane Systolic Excursion; PWT: Posterior Wall Thickness; RWT: Relative Wall Thickness; SD: Standard Deviation; VST: Ventricular Wall Thickness. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001 There is a significant statistically difference between the groups with the letters a and b.*

Regarding the parameters for quantifying the systolic function, the values of the LVSF and LVEF showed a significant increase with age (p = 0,008 and p = 0,024, respectively). In turn, GLS show a decrease with age (p = 0,603).

Table 4 shows low and upper normal limits of the echocardiographic parameters for the present study population by gender and its comparison with 2015 ASE/EACVI guidelines. Our results show that the upper normal limits (UNL) for the LVWT and the left ventricular mass in both, males and females, and the left ventricular end-diastolic diameters and volumes in women are slightly higher than those proposed by the 2015 guidelines. On other hand, in our study, the low normal limits (LNL) for LV GLS are considerably lower than those suggested in the 2015 guidelines.

	Present study, LNL to UNL			Guidelines 2015	
	Male	Female	P Value	Male	Female
VST (mm)	7 to 12	6 to 12	.001***	6 to 10	6 to 9
PWT (mm)	7 to 12	6 to 11	.001***	6 to 10	6 to 9
LVEDD (mm)	39 to 57	36 to 55	.001***	42 to 58	38 to 52
LVEDD/BSA (mm/m^2)	20 to 30	20 to 32	.007**	22 to 30	23 to 31
LVEDV (ml)	55 to 147	55 to 128	.001***	62 to 150	46 to 106
LVEDV/BSA (ml/m^2)	30 to 75	32 to 72	.832	34 to 74	29 to 61
RWT	0.20 to 0.52	0.30 to 0.50	.020*	NA	NA
LVM (g)	92 to 232	57 to 211	.001***	88 to 224	67 to 162
LVM/BSA (g/m^2)	49 to 119	33 to 119	.002*	49 to 115	43 to 95
LVM/height (g/m)	53 to 133	34 to 129	.001***	NA	NA
LVSF (%)	25 to 53	25 to 56	.115	NA	NA
LVEF (%)	51 to 85	56 to 86	.010**	52 to 72	54 to 74
MAPSE (mm)	10 to 20	10 to 20	.841	NA	NA
FEVE/Strain (%)	41 to 64	41 to 63	.910	NA	NA
GLS (%)	-13 to -23	-13 to -24	.226	NA	NA

Table 4: *Low and upper normal limits of the echocardiographic parameters for the present study population by gender and its comparison with 2015 ASE/EACVI guidelines.*

*BSA: Body Surface Area; GLS: Global Longitudinal Strain; LVEDD: Left Ventricular End-Diastolic Diameter LVEDV: Left Ventricular End-Diastolic Volume; LVEF: Left Ventricular Ejection Fraction; LVM: Left Ventricular Masse; LVSF: Left Ventricular Shortening Fraction; MAPSE: Mitral Annular Plane Systolic Excursion; PWT: Posterior Wall Thickness; RWT: Relative Wall Thickness; SD: Standard Deviation; UNL: Upper Normal Limit; VST: Ventricular Wall Thickness. * p ≤ .05 ** p ≤ .01 *** p ≤ .001. LNL and UNL were established as the mean ± 2SD.*

Discussions

In this study, LV cardiac structure, LV systolic function, and LV global longitudinal strain parameters were assessed by echocardiography in a cross-sectional sample of healthy adult Angolans.

Gender-related differences

The main findings of our study shows that LVWT, LVEDD and LVEDV, LVM, and LVM indexed to height and BSA were significantly lower in women ($p < 0.005$). Our results are similar to those reported in others studies performed in other populations: in Brazil [1], Iran [4], Europe [13], sub-Saharan Africa [14], Korea [15] and Turkey [16].

However, the present study showed that LVEDV indexed to BSA loses statistical significance ($p = 0.832$) in the difference between the genders. In turn, the LVEDD indexed to BSA was statistically significantly higher in women compared to men (p = 0,007). Interestingly, in the study carried out in Iran the authors also found that the LVEDD indexed to the BSA was higher in women than in men [4].

Regarding left ventricular function, our study shows that both, LVSF and LVEF were higher in women compared to men. However, only LVEF showed a statistically significant difference between genders (p = 0,01). Our results are consistent with those reported by Asch., *et al*. and Nel S., *et al* [9,14]. On the other hand, Angelo., *et al*. also report a statistically significant difference between genders in the LVSF, but not in the LVEF [1]. Our study does not show any difference between genders in GLS (-18.5 versus -18.0, $p = 0.190$) which contrasts with the one reported by Sullere V., *et al*, Lang., *et al*. and Ash., *et al*. who states that there is evidence that women have slightly higher GSL values when compared to men [5,9,11].

Age-related differences

Concerning age-related differences, our study shows that only PWT increases significantly with age. Although, VST, LVEDD and LVM show an increase with age, it was not statistically significant. On other hand, our study shows that LVSF and LVEF increase significantly with age. On contrary, MAPSE, LVEF strain, and GLS show a reduction with age although they have no statistical significance.

Regarding the data on the influence of age on the LV morphological parameters and the LV systolic function, the existing studies are controversial. Ventricle wall thickness and the LVM are morphological parameters that are very dependent on loading conditions that change physiologically with age, such as arterial blood pressure. Several authors reported an increase in wall thickness and LV mass with age [2-4,15,17] while others, despite presenting an increase in left ventricular mass, did not present statistical significance [1,14]. Our study showed that only the PWT increased significantly with age.

Some studies report that LVEDD and LVEDV reduces with aging [1-3,13,14]. On contrary, in line with another study we did not found a significant change in LVEDD and LVEDV with age [15].

Left ventricular ejection fraction is the echocardiographic parameter with the greatest influence on clinical and therapeutic decisions, and the importance of perceiving its behavior with age is imperative. The results of the aging effect on LV systolic function reported in several studies are also controversial. Some authors showed no change in LVEF [1,2,14], while others reported a decrease in LV systolic function [4,18]. In line with others studies [3,13,19] ours results, also showed an increase in LVSF and LVEF with age.

The limitations of systolic parameters such as LVSF and LVEF are well known, and LV GLS emerges as an innovative technique that allows quantifying sub-clinical changes in LV systolic function, being a technique parameter that does not depend on the load conditions and is capable of presenting subtle changes LV systolic function. Although no statistically significantly, our study showed that the GLS decreased with age, which is consistent with the reported results by Sullere V., *et al*. Lang., *et al*. and Kuznetsova., *et al*. [5,10,19].

Our results versus the normal reference values recommended in 2015 guidelines

The recent American Society of Echocardiography (ASE) and European Association of Cardiovascular Imaging (EACVI) updated recommendations for chamber quantification to define ranges of normative values for the general population using data obtained from welldesigned population-based studies [11]. Although these normative values are used as a reference worldwide, they are derived from data obtained in the United States or specific regions in Europe, thereby reflecting a predominantly white population that is not representative of patients from other races or areas of the world [9]. Reports from Japan [2], China, [3], Iran [4] and India [20] suggest that ''normal'' hearts in those nations are smaller compared with those reported in American and European studies. Furthermore, in the study published by Qureshi., *et al*. gross differences were observed in reference limits for Hispanics/Latinos compared with ASE chamber quantification guidelines [5]. The authors found that both 2005 and 2015 guidelines suggested cutoff underestimate the measures of LVM, VST, and RWT. In contrast, these thresholds overestimated the measures of LVEDV, LVEDD, and PWT in both men and women. These observations depict relatively thicker and smaller healthy hearts in individuals with Hispanic/Latino origin compared with ASE guidelines defined reference values.

In line with the results reported by Qureshi., *et al*. our study also showed that in our population the values of LVWT and left ventricular mass in both men and women are higher than those proposed in the 2015 guidelines [5]. On the other hand, our results showed that the values for left ventricular diameters and volumes in men are very similar to those proposed in the 2015 guidelines, while in women these values are higher than those proposed in the guidelines, even when they are indexed to BSA, which is in agreement with the results of the WASE Normal Values Study [9].

The 2015 guidelines did not provide normal ranges for LV GLS, but only suggested a consensus-based abnormality cutoff value of -20%. The current study provides the lower normal limits for GLS that are considerably lower and are -13% for men and -13% for women, these values are also considerably lower than those found in the WASE Normal Values Study (-17% and -18%, respectively) [9]. These data, however, must be interpreted with caution, as strain analysis to date is vendor-dependent.

Study Limitations

The subclinical disease was not excluded since hemoglobin, thyroid hormone, glucose, and lipid levels were not assessed. We consider the exclusion criteria as demanding to include only healthy adults. However, more complex tests such as impaired glucose tolerance, cardiac catheterization, or diastolic stress echocardiography were not performed to unmask subclinical diastolic dysfunction and symptoms. The sample size may not be sufficient to extrapolate the data presented herein for the Angolan population, but it certainly serves as a reference for future work in this area. The sample of healthy participants aged 60 or more was small. One of the limitations was that a single echocardiographer in the department performed all echocardiograms.

Conclusion

For a more sensitive and correct morphological and functional assessment of the left ventricle, it is necessary to take into account the gender and age of the individual.

Conflicts of Interests

None.

Financing Support

Nothing to declare.

Author's Contribution

Study design: HM and AF.

Data collection: AF.

Writing of the manuscript: HM, AF and SVP.

Revisions and approval of the final manuscript: All authors.

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