RIGHT ATRIAL STRAIN IN A NORMAL ADULT AFRICAN POPULATION AND ITS CORRELATION WITH AGE

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Abstract

Background The right atrial longitudinal strain (RALS) has been shown to be a useful parameter to define right atrial (RA) subclinical dysfunction in several cardiovascular disorders prior to changes in traditional RA two dimensional and volumetric parameters. There is a scarcity of data regarding normal values for RALS in a normal African population. Objectives We sought to establish normal values for RALS and its correlation with age, in a Sub-Saharan black African population. Methods This was a retrospective cross-sectional study of 100 normal individuals (recruited as controls for another study) performed at Chris Hani Baragwanath Hospital (2017-2019). All echocardiographic measurements were done as per standard guidelines. RALS was measured using Philips QLAB 9 (Amsterdam, The Netherlands) speckle-tracking software. Results Median age was 37.5 years (IQR 26-46, 60% females). The mean right atrial volume indexed to body surface area (RAVI) was 19.5 ± 5.7 mL/m² and the mean RALS was 32.7 ± 10.5%. There was a trend towards decreasing RALS with age (r=-0.15, P=0.129) with no change in RAVI with age (P=0.27). Males had a tendency towards higher RAVI and RALS measurements compared to females (20.8 ± 6.3 mL/m² and 18.7 ± 5.2 mL/m², P=0.07; 34.6 ± 9.6% and 31.4 ± 10.9%, P=0.141, respectively). BMI was an independent predictor of RALS on multivariate analysis (r=-0.43, P=0.003) Conclusion We have defined the normal reference values for RALS in a black population. RALS tended to decrease with age prior to change in RAVI and can serve as a marker of subclinical RA dysfunction. BMI was an important determinant of RALS.

ABSTRACT

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Conclusion
We have defined the normal reference values for RALS in a black population. RALS tended to decrease with age prior to change in RAVI and can serve as a marker of subclinical RA dysfunction. BMI was an important determinant of RALS.

Keys words: Right atrial longitudinal strain, Age, African, Echocardiography.

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Authors' contributions:
Mushitu Nyange: collection of data, data analysis/interpretation, drafting article and approved manuscript.
Ruchika Meel: conceptualised, designed study, data analysis/interpretation, drafting article, critical revision of article, approved manuscript.

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Introduction
In the last twenty years, there has been great interest in RA function research, because recent data have demonstrated that, assessment of RA volumetric parameters on echocardiography is an essential predictor of morbidity and mortality in various cardiovascular disorders.(1–3)

There are several imaging studies that have described RA anatomy and function. The RA dimensions, volume, and strain have been studied using cardiac magnetic resonance (CMR) the gold standard, computed tomography, echocardiography (two dimensional and three dimensional) and recently speckle tracking echocardiography (STE). The two-dimensional echocardiography (2DE) has become the most clinically relevant non-invasive technique evaluating the RA.(4–6)

It is important to define normative values of RA strain using 2DE, because RA subclinical dysfunction as measured by strain has been observed in several cardiovascular disorders prior to changes in the traditional indices of RA and RV function such as volume, sizes and ejection fraction. Such cardiovascular disorders include pulmonary arterial hypertension (PAH), coronary artery disease (CAD), and heart failure with
reduced ejection fraction (HFrEF). RA strain had additive prognostic value to other clinical measures, including RV strain, RA area, and RA pressure, in patients with PAH.\(^{(7-11)}\) The difference between normal and abnormal RA dimensions and function is therefore clinically pertinent.

Most of the available studies on RA dimensions parameters in a normal population are depend on data from North America and Europe and are in line with the guidelines of the American Society of Echocardiography (ASE) and European Society of Cardiology (ESC).\(^{(12-15)}\) These values do not effectively represent the diverse racial and ethnic groups of the world.

Study by Soulat-Dufour et al, with the World Alliance Societies of Echocardiography (WASE) have suggested that there might be significant differences in normal values among different populations.\(^{(16)}\) Currently, limited data exist regarding RA volume (RAV), size and strain in a normal black adult African population.

Age-related changes in vascular and cardiac function contribute to cardiovascular mortality. Aging is associated with abnormalities in left-sided functional parameters. However, studies on age-related changes in right-sided functional parameters are scarce.\(^{(17-19)}\)

Thus, in this study, we sought to establish normal values for RAV and RA longitudinal strain (RALS); and its correlation with age, in a Sub-Saharan black African population, using the 2DE and STE.

**Methods**

**Study design and population**

The study is a retrospective analysis of echocardiographic findings in healthy normal controls that formed part of a study (M170389) conducted at Chris Hani Baragwanath Academic Hospital (CHBAH). The inclusion criteria for the prior study included: (i) absence of cardiovascular symptoms, (ii) normal blood pressure (\(\leq 140/90\) mmHg), (iii) absence of diabetes and cardiovascular disease, (iv) not on any chronic medication, and (vi) presence of sinus rhythm (heart rate between 50 and 85 b.p.m). The exclusion criteria were pre-existing: (i) cardiovascular diseases, (ii) pulmonary diseases, (iii) previous abnormal echocardiography, (iv) congenital heart diseases, (v) cardiac pathology detected by echocardiography, (vi) sinus tachycardia (vii) inadequate echocardiographic image quality, and (viii) athlete.

**Ethical considerations**

The current study is a secondary analysis of data collected in healthy controls in the HIV associated ascending aortic aneurysm: clinical features and natural history (M170389). The study was approved by the University of the Witwatersrand ethics committee and conforms to the principles outlined in the Declaration of Helsinki. Permission to use data from the parent study was obtained. The current study was approved by the Human Research Ethics Committee of the University of the Witwatersrand (clearance certificate number: M 200822.). Permission to retrieve and utilize the data was also obtained from Chris Hani Baragwanath Academic Hospital management.

**Echocardiography**

Echocardiograms were obtained according to a standardised protocol on a Phillips iE 33 machine (Amsterdam, The Netherlands) equipped with an S5-1 transducer that transmits a frequency of 1.7 MHz and receives a frequency of 3.4 MHz. All data were analysed offline after being transferred to an Xcelera workstation (Philips). The RALS analysis was performed separately offline using Philips Qlab station 9.0 software.

**Two-dimensional echocardiography**

Measurements of the RA dimensions were performed in agreement with ASE chamber quantification guidelines of 2015 and the 2010 ASE guidelines on right heart assessment. The RA parameters (area and volume) were measured at the end of systole on an apical four-chamber view modified to optimise the RA visualisation. The RAV was measured using the single-plane method of discs by tracing an outline of the RA blood-tissue interface, ensuring that the RA appendage, superior vena cava, and inferior vena cava (IVC) were excluded. The tricuspid tenting area was also excluded.\(^{(12,14,15)}\)
Figure 1. Apical 4 chamber view showing measurement of right atrial volume using method of discs in a normal participant.

Speckle-tracking echocardiography

The RALS was measured using STE, a relatively newer echocardiographic method for obtaining strain and strain rate measurements. For STE using 2D grey-scale echocardiography, apical four-chamber views were captured during breath holding at the end of expiratory phase for few seconds, and with electrocardiogram recording attached. A suitable image of myocardial tissue was obtained completely separated from surrounding structures. Three successive cardiac cycles were recorded and averaged. The frame rate was set between 60 and 80 frames per second. Analysis of speckle-based strain was done using Philips QLAB version 9.0 software. In four chamber RA focused views, the endocardial surface of the RA was traced manually by a three-point and-click approach. The system automatically generates an epicardial surface tracing. The region of interest (ROI) was therefore created, composed of 7 segments. The ROI was manually adjusted as needed to allow for enough speckle tracking. The software generates the longitudinal curves for each segment with its mean value. (20–22) (Figure 2)
Figure 2. Speckle tracking echocardiography showing decreased peak right atrial longitudinal strain of 25.5% (A) in an older subject compared to younger subject (B) of 46.5%.

Sample size calculation and subgrouping according to age

The number of healthy controls who were enrolled in the parent study was 100. All 100 controls were included as study participants in the current study. Using the power command in Stata, we conducted a one-sample correlation test to estimate the minimum sample required to detect a correlation of at least r=0.3 between RALS and age. The minimum sample size required was 100. All participants were subdivided into three age groups (Group 1: 18-29 years, Group 2: 30-39 years, Group 3: 40-49 years and Group 4: 50-70 years).

Data collection

The current study is a secondary data analysis, and we utilized data from an existing database. Only variables in our data collection sheet were used in the current study.

Statistical analysis

Descriptive statistics

Continuous variables were described using the mean and standard deviation, or median and interquartile range when variables were not normally distributed. The independent t-test was used to compare means of continuous variables by sex while the Mann-Whitney test for comparison of median values by sex. One way analysis of variance (ANOVA) was used to compare means of normally distributed continuous variables by
age group or BMI category, while Kruskal Wallis was used for comparison of medians when variables were not normally distributed. Pearson’s correlation coefficients determined the association between age and RA parameters using a statistical significance threshold of 0.05. All statistical analyses were conducted in Stata version 15.

**Inferential statistics**

Univariate and multivariable linear regression was used to explore the association between RALS and independent variables at presentation (age, sex, body mass index, BSA and RV parameters). Independent variables were selected a priori for multivariate analyses. All clinically relevant and/or statistically significant variables on univariate analysis with \( P \text{ value} \leq 0.1 \) were included in the multivariate analysis.

**Results**

**Demographic characteristics of the study population**

Baseline characteristics of the overall population of the study are presented in Table I. A total of 100 participants were included, with a median age of 37.5 years (IQR 26-46) with 60% female, and 24% of participants were above 50 years of age. Weight differed by age group (\( P=0.049 \)) and the median BMI was 28.0 (24.0-34.9) kg/m\(^2\). A greater percentage of female participants were overweight and obese (50%). There was an age-related increase in BMI of all participants, but it was not statistically significant (\( P=0.089 \)).

<table>
<thead>
<tr>
<th>Variable*</th>
<th>Total (20-62 Years) n= 100</th>
<th>Group 1 (18-29 Years) n= 27</th>
<th>Group 2 (30-39 Years) n= 28</th>
<th>Group 3 (40-49 Years) n= 21</th>
<th>Group 4 (([?]50) Years) n=24</th>
<th>P value++ (ANOVA)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical parameters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (Years)</td>
<td>37.5 (29.0-48.0)</td>
<td>25.0 (23.0-28.0)</td>
<td>34.0 (33.0-37.0)</td>
<td>45.0 (42.0-47.0)</td>
<td>54.0 (51.0-57.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>160.7 ± 7.3 (65.0-85.0)</td>
<td>161.6 ± 8.2 (59.0-75.0)</td>
<td>160.6 ± 6.5 (65.0-86.5)</td>
<td>162.0 ± 6.4 (64.0-87.0)</td>
<td>158.8 ± 7.9 (69.3-84.5)</td>
<td>0.499</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>73.0 ± 7.3 (24.0-34.9)</td>
<td>67.0 ± 7.3 (22.5-29.3)</td>
<td>73.0 (24.2-35.4)</td>
<td>80.0 (26.6-34.3)</td>
<td>78.3 (27.1-36.6)</td>
<td>0.049</td>
</tr>
<tr>
<td>Sex; Female n (%)</td>
<td>60 (60.0%)</td>
<td>13 (48.2%)</td>
<td>18 (64.3%)</td>
<td>10 (47.6%)</td>
<td>19 (79.2%)</td>
<td>0.078</td>
</tr>
<tr>
<td>Body mass index (kg/m(^2))</td>
<td>28.0 (24.0-34.9)</td>
<td>24.0 (22.5-29.3)</td>
<td>29.1 (24.2-35.4)</td>
<td>29.0 (26.6-34.3)</td>
<td>30.8 (27.1-36.6)</td>
<td>0.089</td>
</tr>
<tr>
<td>Body surface area (m(^2))</td>
<td>1.8 ± 0.2 (1.8 ± 0.2)</td>
<td>1.7 ± 0.2 (1.8 ± 0.2)</td>
<td>1.8 ± 0.2 (1.8 ± 0.2)</td>
<td>1.8 ± 0.2 (1.8 ± 0.2)</td>
<td>1.8 ± 0.1 (1.8 ± 0.1)</td>
<td>0.168</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>126.8 ± 12.4 (79.3 ± 10.3)</td>
<td>123 ± 11.6 (76.9 ± 10.9)</td>
<td>126 ± 14.0 (79.2 ± 11.6)</td>
<td>127 ± 9.1 (80.5 ± 9.3)</td>
<td>130.8 ± 13.2 (80.9 ± 9.0)</td>
<td>0.205</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>72.0 (62.5-82.0)</td>
<td>76.9 ± 10.9 (67.0-85.5)</td>
<td>75.5 (61.0-82.0)</td>
<td>70.0 (62.5-81.5)</td>
<td>71.0 (62.5-81.5)</td>
<td>0.498</td>
</tr>
</tbody>
</table>
Data reported as means ±SD or median (IQR). Abbreviations: SD standard deviation interquartile range, † Kruskall-Wallis p value for non-normally distributed variables. ++ Statistical significance denoted by p values <0.05.

Two-dimensional echocardiography parameters according to age groups are depicted in Table II.

There were no statistically significant differences with regard to age related RA volumetric measurements (P=0.271). RALS had a trend towards decreasing with age but did not achieve statistical significance (P=
0.362). RAVI and RALS had a negative correlation with age but did not reach statistical significance (r = -0.060, P = 0.526; r = -0.153, p value = 0.129 respectively (Figure 3).

Figure 3. Right atrial volume (ml/m²) and right atrium longitudinal strain negatively correlated with age of participants age (r = -0.060, P = 0.526; r = -0.153, p value = 0.129 respectively).

Regarding traditional RV functional parameters (TAPSE, RV E’, A’, and RV S’) there were no statistically significant differences. RV diastolic function declined with age with RV E’/A’ showing a decrease with age (P= 0.002). Left ventricular diastolic function parameters showed a decrease with age but remained within ASE guideline specified normal limits (P<0.001).

Echocardiographic parameters according to gender are depicted in Table III

Males had a tendency towards a higher RAVI and RALS measurements compared to females (20.8 ± 6.3 mL/m² and 18.7 ± 5.2 mL/m², P=0.07: 34.6 ± 9.6% and 31.4 ± 10.9 %, P=0.141, respectively). There were no statistically significant differences in RV measurements and function parameters between males and females. All participants had LV diastolic pulsed-wave (trans-mitral E and A waves) and tissue doppler measurements within the normal accepted guideline range except for A wave and A’ lateral which were higher in females compared to males (P=0.001 and P=0.004, respectively). Male participants had higher LV end-diastolic and end-systolic dimensions and volumes, as well as LA volume indexed to BSA.

Clinical and Echocardiographic Indices according to body mass index are depicted in Table IV

Twenty three percent of participants were overweight and 44% were obese. Obese participants had higher heart rate than non-obese participants (p=0.002) There were no statistically significant differences with regard to RA volumetric measurements, but RALS had a tendency to decrease with increasing BMI (35.7 ± 9.3%, <25 kg/m²; 34.6 ± 11.4, <30 kg/m² ; and 29.9 ± 10.1, >30 kg/m² respectively, P=0.571). RV E’ / A’ ratio decreased with increasing BMI (P=0.020) suggestive of worsening RV diastolic dysfunction with increasing BMI. LA volume and size increased with an increasing BMI (P= 0.010 and P <0.001, respectively).

Similar to RV diastolic parameters there was worsening of LV diastolic function with an increase in BMI.

Determinants of right atrial longitudinal strain are depicted in Table 5

BMI was an independent predictor of RALS (i.e., BMI was a statistically significant variable on both univariate and multivariate analyses). BMI negatively correlated with RALS (r=-0.43, P=0.003). For example, in the adjusted analyses, a unit increase in BMI resulted in a 0.72 decline in RALS.

Table V. Multiple linear regression analysis for predictors of right atrial longitudinal strain

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Univariate regression</th>
<th>Univariate regression</th>
<th>Univariate regression</th>
<th>Multivariate regression</th>
<th>Multivariate regression</th>
<th>Multivariate regression</th>
<th>Multiple R, (P value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>? coefficient</td>
<td>Standard error</td>
<td>P value</td>
<td>? coefficient</td>
<td>Standard error</td>
<td>P value</td>
<td>0.40 (0.097)</td>
</tr>
<tr>
<td>Male sex</td>
<td>3.17</td>
<td>2.13</td>
<td>0.141</td>
<td>-1.15</td>
<td>2.80</td>
<td>0.683</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>-0.43</td>
<td>0.14</td>
<td>0.003</td>
<td>-0.72</td>
<td>0.29</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td>BSA</td>
<td>-6.61</td>
<td>6.30</td>
<td>0.297</td>
<td>16.20</td>
<td>10.28</td>
<td>0.118</td>
<td></td>
</tr>
<tr>
<td>RV S’</td>
<td>0.81</td>
<td>0.51</td>
<td>0.114</td>
<td>0.47</td>
<td>0.56</td>
<td>0.410</td>
<td></td>
</tr>
<tr>
<td>RV Base</td>
<td>0.0004</td>
<td>0.21</td>
<td>0.998</td>
<td>-0.10</td>
<td>0.22</td>
<td>0.644</td>
<td></td>
</tr>
</tbody>
</table>
Covariates | Univariate regression | Univariate regression | Univariate regression | Multivariate regression | Multivariate regression | Multivariate regression | Multiple R, (P value)
---|---|---|---|---|---|---|---
RV E' | 0.49 | 0.33 | 0.149 | 0.98 | 0.73 | 0.186
RV A' | -0.11 | 0.36 | 0.764 | -0.65 | 0.75 | 0.387
RV E'/A' ratio | 2.11 | 2.02 | 0.298 | -5.77 | 5.76 | 0.319
RA volume/BSA ratio | -0.19 | 0.18 | 0.307 | -0.20 | 0.19 | 0.307

**Abbreviations**: BMI body mass index, BSA body surface area, RA right atrial, RV Right ventricle.

**Discussion**

This is the first study to provide normative age-related data for RALS in a Sub-Saharan African population. Additionally, we have also provided supplementary data regarding RAVI according to age and gender in this population. RALS had a tendency to decrease with age concurrent with a decline in RV diastolic function despite no alteration in RAVI, and BMI was an important independent predictor of RALS. Even though there was a tendency for RAVI to be higher in males, RAVI and RALS were not influenced significantly by gender.

Previous studies using 2DE by Y. Wang et al. in 1984, and S. Kou et al. from the Normal Reference Ranges for Echocardiography (NORRE) study 2013, were focused on Caucasian populations, and were in line with the ASE and ESC 2015 chamber quantification guideline document, which states that RAVI should be <33 mL/m² (or <35 mL/m² in men and <31 mL/m² in women)\(^{(23,24)}\). In this study we found that, while the lower limits were similar to those of ASE and ESC guidelines, the upper margins were much lower (20.8 ± 6.3 mL/m² in males and 18.7 ± 5.2 in females). Studies in African and Asian populations by Nel et al. and Asian by Karki et al. respectively have also observed the same pattern.\(^{(25,26)}\) Soulat-Dufour with WASE study 2,008 healthy adult individuals around the world, has shown that generally, Asian subjects have lower BSA compared to subjects in non-Asian countries.\(^{(16)}\) Ethnicity may cause variation in genetics and parameters of BSA and BMI and thus may directly influence echocardiographic measures. Thus, correlation between ethnicity and RA volumetric parameters is important.

In this study, there was a trend towards higher RAVI in males when compared to females but no influence of age on RAVI was noted. The aforementioned finding was akin to the recent study by Nel et al. and the WASE pertaining to RAVI in a normal population. Grünig et al. and D’Ascenzi et al. have shown that males have a larger RA area compared to females, explaining volume differences between the gender.\(^{(27,28)}\) D’Oronzio et al., Y. Wang et al. and Peluso et al. using 2DE and 3DE respectively, did not find any correlation between atrial volume and ageing for reasons that are not fully understood.\(^{(23,29,30)}\) In the current study the mean RALS was 32.7 ± 10.5%, which was lower than the value reported by Padeletti et al. and D’Ascenzi et al.\(^{(22,28)}\) In the aforementioned Italian comprising 84 and 74 subjects, RALS was documented using the 2D STE and the mean RALS was 49 ± 13% and 48 ± 12.68% respectively.\(^{(22,28)}\) The above-mentioned studies were done in a group of subjects with overall lower BMI (22.4 ± 3.5 kg/m²) in contrast to the current study (24-34.9 kg/m²) and, is the likely explanation for higher RALS in their cohort. The following paragraph describes in detail the influence of obesity on RALS.

Obesity has been a health problem of growing significance all over the world; its prevalence is increasing in both developed and developing countries. According to WHO data, 39% of the global population above 18 years of age are overweight and of these, 13% are obese. In Africa there is a significant obesity trend, with increases in BMI documented in both gender.\(^{(36)}\) Miclesfield et al. studied South Africa population from Soweto and demonstrated a significant gender difference with regard to BMI, with women being remarkably overweight and obese.\(^{(37)}\)
In this study 67% of normal volunteers had BMIs above 25 kg/m$^2$, which occurred more commonly in women (49%). BMI was the only independent predictor of RALS in this study. An inverse relationship was noted between BMI and RALS in the current study. Recent study by Chirinos et al. quantified left atrium (LA) strain and strain rate (SR) via STE among 1,531 middle-aged community-based participants enrolled in the Asklepios study. They demonstrated that longitudinal LA strain measured using STE decreased with elevated BMI. (33)

Obesity has been shown to have many effects on cardiovascular structure and function. Excess adiposity imposes an increased metabolic demand on the body and both cardiac output and total blood volume are elevated in obesity leading to a hyperdynamic circulation, which causes LV and RV structural changes in obesity and subsequently leads to increased ventricular mass and cavity dilatation. Obesity is the main lead in tissues fibrosis formation. (38) Sokmen et al., and Csige et al. showed that uncomplicated obesity was associated with RV and RA dilatation, and increased thickness of the RV free wall. Also, these structural indices were found to be positively correlated with BMI. Myocardial fat accumulation as a consequence of obesity, may cause atrial interstitial fibrosis and subsequently atrial dilatation and stiffness. (39, 40) This may be a possible mechanism explaining the inverse relationship of BMI and RALS in this study, that obesity may result in RA fibrosis, stiffness with a consequent reduction in myocardial deformation and RALS.

Furthermore, this study demonstrates that RALS tended to decrease with age and males tended to have higher values compared to females, though this finding did not reach statistical significance.

Aging is associated with the development of myocardial fibrosis. Fibrotic tissue is stiffer and less compliant, resulting in subsequent cardiac dysfunction. (31, 32) We hypothesised that a combination of stiff RA and RV diastolic dysfunction associated with age related myocardial fibrosis will have a poor myocardial deformation and this may result in age related decrease in RALS. However, we did not perform biomarkers or CMR imaging to objectively assess for presence of fibrosis in this study. The trend towards gender differences of RALS (though not statistically relevant) could be multifactorial in this study. In addition to a difference in biology, a higher BMI in females compared to males may explain the aforementioned finding. Male participants were also younger and had higher RAVI and likely more compliant RA compared to females which translated into higher RALS. Further, males had a lower heart rate compared to females (65.0 (59.0-76.5) beats/min vs 76.0 (67.0-82.5) beats/min, P=0.002) which allowed for a prolonged filling time of RA chamber and thus increased stretch of the right atrial wall with resultant higher RALS.

Padeletti et al. did not find differences in RALS gender and ageing. This lack of association between RALS, gender and aging may be related to the limited capacity of the software in identifying all the segments of the RA due to the higher tricuspid annulus deformation compared to the mitral valve. Furthermore, this may be attributed to varying sample sizes and racial differences in the two studies. With the recent technologies Nemes et al., and Yang-Yang Qu et al. using three-dimensional speckle tracking echocardiography (3DSTE) and CMR respectively, have demonstrated obvious gender differences in RA strain. In contrast to our findings, they noted RA strain to be higher in females and showed an age related decline in both genders. (34, 35) The differences in analysis software and technique used by the above-mentioned studies may explain the discordances in results. Further studies are warranted to confirm our findings in a larger African population and also to further assess RALS. We have also confirmed the utility of RALS as a marker of subclinical disease in this population as we did not see changes in RAVI with age but noted a trend towards lower RALS with increasing age. Thus, RALS may anticipate the RA impairment in diseases prior to changes in traditional parameters such as RA size and volumes. This may aid in earlier diagnosis of disease and prompt treatment strategies at a subclinical stage of the disease.

**Study limitations**

In addition to the inherent limitations of a retrospective study this study had further study limitations:

1. A minority of subjects were older than age 60 years, due to a lower life expectancy in a South African population (the average life expectancy of an adult in 2014 was estimated at 59.1 years for males and
63.1 years for females, according to Statistics South Africa).(41)

2. RA strain measurement values vary with different vendors and software packages,

3. exercise capacity of the study subjects was not assessed to unmask subclinical diastolic dysfunction and symptoms, and

4. Being a secondary data analysis, sample size was restricted to what was collected in the parent study, a larger sample size might have been able to detect finer differences.

5. Majority of the patients were obese or overweight and is a reflection of the current “normal” South African population.

6. We did not do blood tests to screen for diseases such as diabetes, renal dysfunction and hyperlipidaemia or additional imaging or biomarkers for assessment of fibrosis.

Conclusion

We have presented the first normative values for RALS in sub-Saharan African population. Normal ageing was associated with a trend towards declining RALS with preserved RAVI, and BMI was inversely related to RALS. The normative data on RA strain and volumes according to age, will help in differentiating normal from abnormal RA function and thus help in cardiovascular diseases risk stratification in this population. Further, this study provides a platform for future larger studies on RALS.

References


