Original Article

Transthoracic Echocardiographic Assessment of Thoracic Aorta: Correlation with Cardiovascular Risk Factors

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Abstract

Background: Thoracic aorta dimensions have been poorly correlated with cardiovascular risk factors such as systemic arterial hypertension (SAH), diabetes mellitus (DM) and coronary artery disease (CAD).

Objectives: To correlate the thoracic aorta diameter assessed by transthoracic echocardiography (TTE) with SAH, DM, dyslipidemia, CAD, smoking, age, gender, weight, height, body mass index (BMI) and body surface area (BSA) and continuous use of drugs with cardiovascular protective action.

Methods: Observational, cross-sectional and retrospective study. The study included 203 individuals (62.1 ± 15.3 years of age; 57.1% female) who underwent TTE with thoracic aorta evaluation at 6 sites: (1) aortic valve annulus; (2) sinus of Valsalva; (3) sinotubular junction; (4) ascending proximal aorta; (5) aortic arch and (6) descending aorta.

Results: Age ($p < 0.05$), male gender ($p < 0.001$), weight ($p < 0.001$), height ($p < 0.05$), and BSA ($p < 0.001$) were associated with greater thoracic aorta diameters at all sites evaluated. Multivariate analysis identified that age, male gender and BSA, together, explain the variation of aortic annulus diameters in 17.3%, in the sinus of Valsalva in 30.7%, in the sinotubular junction in 17.7%, in the proximal ascending aorta in 21.9%, in the aortic arch in 19.8% and in the descending aorta in 21.4%. There was no association between aortic diameters and the risk factors assessed and continuous use of beta-blockers, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers.

Conclusions: Age, male gender and body surface area correlated positively and significantly with the thoracic aorta diameters. (Arq Bras Cardiol: Imagem cardiovasc. 2018;31(3):191-197)

Keywords: Aorta,Thoracic; Dilatation,Pathologic; Echocardiography; Risk Factor; Drug Utilization.

Introduction

Thorough evaluation of the biophysical properties of the aorta can yield much information about the physiopathology of the aorta, providing prognostic information, including clinical implications, on both disease states and on the general population.[1-3] The normal diameter of the ascending aorta is defined as < 2.1 cm/m², of the descending aorta as < 1.6 cm/m² and of the abdominal aorta as smaller than 3.0 cm.

It is known that some factors are associated with the dimensions of the thoracic and abdominal aorta, such as age, body surface area[4] and intra-arterial pressure.[3] Mao et al.[5] found a significant linear association between age, male gender and thoracic aorta diameter in tomographic and hemodynamic measurements. Direct associations of the aortic root dimensions with diastolic arterial pressures and inverse associations with pulse and systolic blood pressure have also been found.[6]

Wolak et al.[7] managed to correlate age, body surface area, male gender and systemic hypertension with the dimensions of the thoracic aorta through computed tomography. However, in this study, diabetes was associated only with increased ascending aorta diameter and smoking was associated with increased descending aorta diameter. Likewise, the presence of atherosclerotic plaques in the aorta was poorly associated with distal dilation of the aorta, suggesting that atherosclerosis plays a minor role in aortic dilation in the population.

Agmon et al.,[8] in an article of echocardiographic measurements, showed that aortic dilation was weakly associated with cardiovascular risk factors, atherosclerosis and atherosclerotic plaques. Some drug therapy options for aortic aneurysms, such as angiotensin-converting enzyme inhibitors (ACEI), angiotensin receptor blockers (ARBs), beta-blockers or statins, have shown conflicting results, probably because of multiple factors of aneurysm formation.[9] Thus, the relationship between echocardiographic measurements of the thoracic aorta and cardiovascular risk factors, and the use of cardioprotective drugs is not clear.

Considering the above, the objective of this study was to evaluate the correlation between thoracic aorta diameters

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evaluated by TTE with anthropometric variables (gender, age, weight, height, body mass index [BMI] and body surface area), traditional cardiovascular risk factors such as systemic arterial hypertension (SAH), diabetes mellitus (DM), coronary artery disease (CAD), smoking and dyslipidemia, and continuous use of cardiovascular protective drugs such as ACEI, ARBs, calcium channel blockers, and beta-blockers.

Methods

Observational, cross-sectional and retrospective study. The study included 230 patients who underwent transthoracic echocardiography in a public reference hospital during 2016. Individuals should have electronic records including two-dimensional echocardiographic reports with thoracic aorta diameters, following the guidelines of Lang et al.,[3] for the following: (1) aortic valve annulus; (2) sinus of Valsalva maximum diameter; (3) sinotubular junction (usually a transition between the sinuses of Valsalva and the tubular portion of the ascending aorta); (4) maximal diameter of the ascending proximal aorta measured 4 cm from the sinotubular junction; (5) aortic arch (segment between the brachycephalic trunk and the origin of the left subclavian artery) and (6) descending aorta (measured in parallel and at the height of the aortic root at a 90-degree angle to the artery wall). Information was also collected from the electronic medical records regarding age, gender, weight, height, body mass index (BMI), body surface area (BSA), cardiovascular risk factors (SAH, DM, CAD, smoking and dyslipidemia) and use of medications such as beta-blockers, ACEIs, ARBs, diuretics, and calcium channel blockers. BMI and body surface area (BSA) were calculated using the Mosteller method. Diagnoses of SAH, DM, dyslipidemia and smoking appeared on the patients' records. The presence of CAD was confirmed by medical record data including nonfatal myocardial infarction and surgical or percutaneous coronary artery bypass grafting. The data were noted down, along with the aorta measurements, in the attached protocol. The following echocardiography equipment were used: IE33 (Phillips), Envisor (Phillips) and Vivid e (GE), all with harmonic imaging software enabled. The tests were conducted by three experienced echocardiographers with echocardiography certificates issued by the Department of Cardiovascular Imaging of the Brazilian Society of Cardiology (DIC/SBC). The exclusion criteria were: patients under 15 years of age, unsatisfactory acoustic window to obtain all thoracic aorta measurements, presence of moderate to severe aortic valve regurgitation and previous aortic valve replacement surgery. This study was approved by the local Research Ethics Committee.

Statistical Analysis

Data on quantitative variables were described by means and standard deviations. For the qualitative variables, frequencies and percentages were presented. The association between two quantitative variables was evaluated by estimating the Pearson's correlation coefficient. To compare two groups defined by gender or by the presence or absence of cardiovascular risk factors, regarding the quantitative variables, Student's t test for independent samples was used. The normality of the variables was evaluated by the Kolmogorov-Smirnov test. For the multivariate analysis, Multiple Linear Regression models were adjusted for the aortic diameters, including age, gender and body surface area as explanatory variables. The parameters estimated for age and body surface area indicate the change in aortic diameter (in cm) per change unit in these variables. The parameter estimated for gender corresponds to the change in aortic diameter if the patient is male. For each model, the coefficient of determination R^2 was presented, which expresses the percentage of aortic diameter variability, which is explained by the variations in age, gender and body surface area. Statistical significance was considered when $p < 0.05$. The data were analyzed using the IBM SPSS Statistics v.20 computer program.

Results

A total of 27 patients were excluded (11.7% of the sample) due to technical difficulties in obtaining measurements of thoracic aorta, bad acoustic windows, previous aortic valve replacement surgery, or moderate to severe aortic reflux. Of the final sample (n = 203), 116 (57.1%) patients were female with a mean age of 62.1 ± 15.3 years. Regarding the presence of risk factors, there was a predominance of SAH in 147 individuals (72.4%) and dyslipidemia in 78 individuals (38.4%). Continuous use of beta-blockers was found in 103 individuals (50.7%) and continuous use of ACEIs or ARBs in 139 (68.5%). The other cataloged medications were used by a few patients not reaching a significant N for statistical analysis (only 6 patients used calcium channel blockers). The descriptive characteristics of the study population as well as the thoracic aorta values are shown in Table 1 and 2 and in Figure 1.

Univariate analysis

The variables age ($p < 0.05$), male gender ($p < 0.001$), weight ($p < 0.001$), height ($p < 0.05$) and body surface area ($p < 0.001$) were positively and significantly associated with larger aorta diameters on TTE at all sites assessed (Tables 3 and 4; Figures 2 and 3). Larger BMI values also corresponded to larger aortic diameters at all sites ($p < 0.05$), except in the sinus of Valsalva ($p = 0.297$) and in the sinotubular junction ($p = 0.169$).

Table 1 – Clinical and echocardiographic variables (N = 203)

Variable	Result (mean ± SD)
Age (years)	62.1 ± 15.3
Female gender (N/%)	116/57.1
Weight (kg)	76.9 ± 16.6
Height (m)	1.64 ± 0.1
Body surface area (m^2)	1.83 ± 0.21
BMI (kg/m^2)	28.5 ± 5.9
SAH (N/%)	147/72.4
Dyslipidemia (N/%)	78/38.4
Smoking (N/%)	66/32.5
Diabetes (N/%)	51/25,1
CAD (N/%)	44/21.7

The presence of SAH and the use of beta-blockers presented a statistically significant relationship with aortic diameter only in the aortic arch (p = 0.028) and descending aorta measurement (p = 0.027), respectively. There was no association between the aorta diameter and other variables, such as DM, CAD, dyslipidemia, smoking and use of ACEI/ARB.

Multivariate analysis

It was found that age, male gender and body surface area, together, explain the diameter variation in the aortic annulus by 17.3%, in the sinus of Valsalva by 30.7%, in the sinotubular junction by 17.7%, in the ascending proximal aorta by 21.9%, in the aortic arch by 19.8% and in the descending aorta by 21.4%.

Table 2 – Thoracic aorta dimensions at the sites of measurement in the studied population

Echocardiographic measurements of the aorta (cm)	Mean ± standard deviation
Aortic annulus	2.55 ± 0.35
Sinus of Valsalva	3.37 ± 0.42
Sinotubular junction	3.10 ± 0.42
Proximal ascending aorta	3.39 ± 0.52
Aortic arch	2.43 ± 0.39
Descending aorta	2.10 ± 0.29

Discussion

In this study, we found a very heterogeneous sample regarding age, weight, height and body surface area. These characteristics contributed to a broad analysis, since previous studies suggested correlation of aortic diameter with these variables. In this sample, however, a selection bias was found, due to the fact that the selected patients, coming from public health services, were mostly referred to the echocardiography outpatient service to investigate preexisting diseases or conditions. This contributed to the high rate of diseases and risk factors found in the sample, where 72.4% had systemic arterial hypertension, 25.1% had diabetes mellitus, 21.7% had coronary artery disease, 32.5% had a history of smoking and 38.4% had dyslipidemia. The same bias influenced us to find a high rate of use of medications such as ACEI or ARBs and beta-blockers. The fact that we had a sample with a high rate of diseases, risk factors and medication use, however, corroborated with the study's proposal to correlate these variables with the thoracic aorta diameters.

Transthoracic echocardiography has become the most widely used imaging method for evaluating cardiovascular disease and has clinical relevance for the diagnosis and follow-up of aortic diseases.[10] Many of the estimated values for normal aortic root dimensions considering age and body surface area as well as the prevalence and prognostic significance of aortic dilatation in adults came from transthoracic echocardiography.[11]

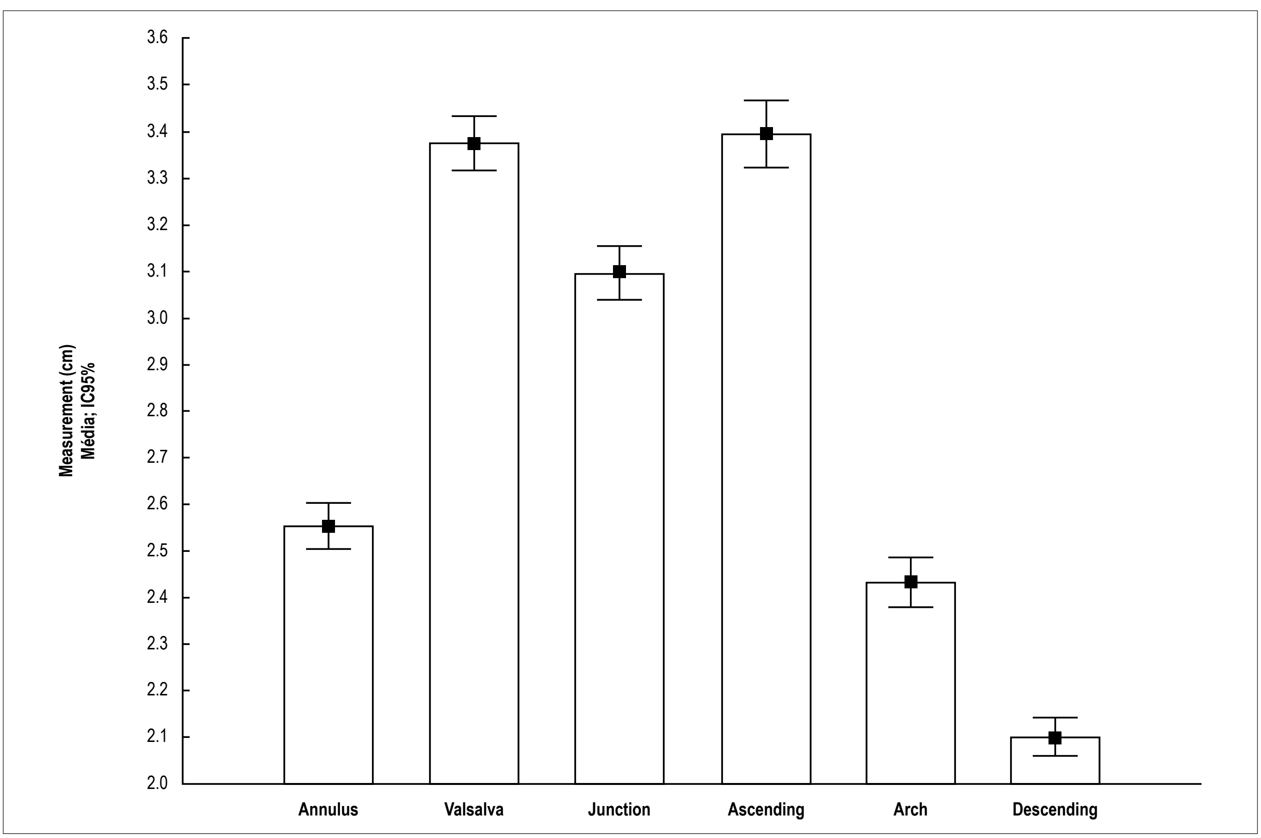

Figure 1 – *Means and confidence intervals of aortic echocardiographic diameters at each site of measurement.*

Table 3 – Diameter of the aorta at six sites, stratified by gender

Gender	AAN	SV	STJ	PAA	AA	DA
M	2.68 ± 0.4	3.61 ± 0.4	3.26 ± 0.4	3.59 ± 0.6	2.55 ± 0.4	2.19 ± 0.3
	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001
F	2.46 ± 0.4	3.20 ± 0.3	2.97 ± 0.4	3.25 ± 0.4	2.34 ± 0.3	2.03 ± 0.3
	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001

Results expressed as cm by mean ± standard deviation. Student's t-test for independent samples, p < 0.05. M: male; F: female; ANA: aortic annulus; SV: Sinus of Valsalva; STJ: sinotubular junction; PAA: proximal ascending aorta; AA: aortic arch; DA: descending aorta.

Table 4 – Correlation coefficients (r) between the aortic diameters and the variables age, weight, height, body mass index (BMI) and body surface area (BSA)

	AAN	SV	STJ	PAA	AA	DA
Age	r = 0.15	r = 0.18	r = 0.16	r = 0.26	r = 0.26	r = 0.27
	p = 0.038	p = 0.009	p = 0.022	p < 0.001	p < 0.001	p < 0.001
Weight	r = 0.32	r = 0.31	r = 0.27	r = 0.31	r = 0.33	r = 0.33
	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001
Height	r = 0.24	r = 0.40	r = 0.29	r = 0.23	r = 0.17	r = 0.22
	p = 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001
BMI	r = 0.18	r = 0.07	r = 0.10	r = 0.18	r = 0.22	r = 0.20
	p = 0.009	p = 0.297	p = 0.169	p = 0.012	p = 0.001	p = 0.005
BSA	r = 0.37	r = 0.43	r = 0.34	r = 0.35	r = 0.34	r = 0.36
	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001

AAN: aortic annulus; SV: sinus of Valsalva; STJ: sinotubular junction; PAA: proximal ascending aorta; AA: aortic arch; DA: descending aorta.

The literature shows that aorta dimensions are influenced by age, sex, height, weight and body surface area,[3,6,12-16]. The findings of this study corroborate with the literature in this regard, since a direct relationship has been found between the diameter of all thoracic aorta segments (aortic annulus, sinus of Valsalva, sinotubular junction, proximal ascending aorta, aortic arch and descending artery) and age, male gender, weight, height and body surface. However, a significant association of aortic diameters with the presence of SAH was expected, since it is considered the most prevalent risk factor for acute aortic dissection.[17]

In this study, the presence of SAH showed an independent relationship only with the two-dimensional measurements of the aortic arch. Although this finding is significant for this segment, it shows that its role as a major risk factor for thoracic aortic dilatation is questionable, which is consistent with the findings of other studies.[8,18,19] However, it is worth emphasizing that the high prevalence of hypertension in the studied population, without the presence of a similar control group of non-hypertensive individuals, and the lack of information regarding proper blood pressure control or no control, does not allow a precise evaluation of its influence on the thoracic aorta diameters. Besides, a prospective study comparing the progression of thoracic aorta dimensions between hypertensive individuals with and without medication would be unethical. A study evaluating the thoracic aorta dimensions using three-dimensional echocardiography and computed tomography without contrast on hypertensive and non-hypertensive male patients found a significant influence of hypertension on aorta diameters regardless of age. The authors concluded that the presence of hypertension produces an increase of 2 to 7 years of age in each hypertensive individual.[20] In this study, the small prevalence of non-hypertensive individuals did not produce a statistically significant result on the two groups, with the age factor remaining the biggest influencer of aortic dimensions.

Likewise, influence of other risk factors for atherosclerosis on the thoracic aorta dimensions was expected, which did neither occur in this study or in the study by Agmon et al.[8] Some studies have found a correlation between smoking, diabetes and hypertension with increased aortic diameter.[7,8,13-14,21] They also found a weak association, by statistical inference, between cardiovascular risk factors, atherosclerosis and aortic dilatation.[7,8,13,22]

The role of high blood pressure, smoking, diabetes and atherosclerosis as risk factors for thoracic aortic dilatation is unclear. The presence of these diseases, as well as the presence of cardiovascular risk factors, did not have any significant correlation with the thoracic aorta diameters found in this study.

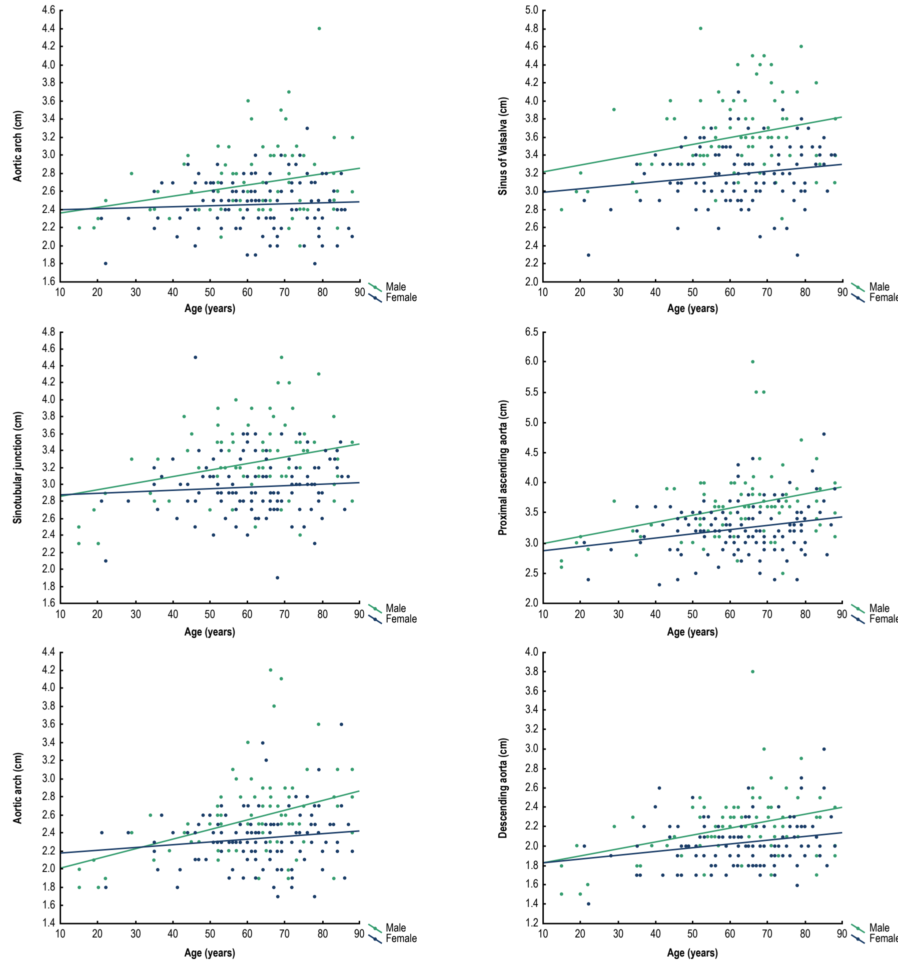

Figure 2 – *Dispersion diagrams corresponding to the aortic dimensions as a function of age and according to gender.*

Another study had not found any correlation between aortic diameters and drug treatment with ACEI, ARBs or beta-blockers.[9] Continuous use of beta-blockers, ACEI or BRA did not correlate significantly with the aortic diameters found in the study population either. These findings, however, do not make the use of these medications unnecessary, as these are highly recommended for the control of aortic disease,[23-24] and are part of the tools required for the treatment of cardiovascular diseases. Therefore, a study capable of evaluating the use of each medication and its independent influence on the thoracic aorta diameters would be virtually impossible, since most of the risk factors and their treatment occur on a concomitant and complementary basis.

Conclusion

This study allowed us to conclude the thoracic aorta diameters evaluated by transthoracic echocardiography if they correlated significantly with age, male gender and body surface area. Traditional risk factors such as SAH, diabetes, smoking and CAD did not influence the measures found.

Authors' contributions

Research creation and design: Barbosa AS, Camarozano AC, Carmo DC, Rafael D, Fortunato JA, Darwich RZ, Baroncini LAV; Data acquisition: Barbosa AS, Camarozano AC, Carmo DC, Rafael D, Fortunato JA, Darwich RZ, Baroncini LAV; Data analysis and interpretation: Barbosa AS, Camarozano AC, Baroncini LAV; Statistical analysis: Barbosa AS, Baroncini LAV; Manuscript writing: Barbosa AS, Camarozano AC, Baroncini LAV; Critical revision of the manuscript as for important intellectual content: Barbosa AS, Camarozano AC, Carmo DC, Rafael D, Fortunato JA, Darwich RZ, Baroncini LAV.

Potential Conflicts of Interest

There are no relevant conflicts of interest.

Sources of Funding

This study had no external funding sources.

Academic Association

This study is not associated with any graduate program.

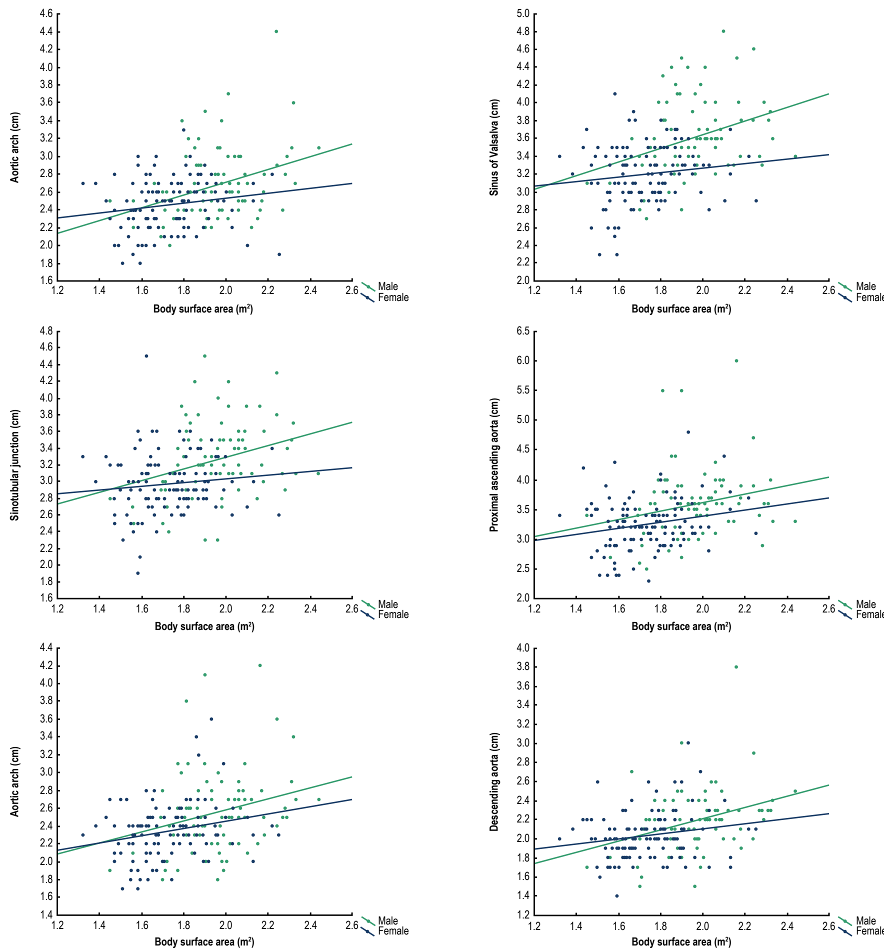

Figure 3 – *Dispersion diagrams corresponding to aortic dimensions as a function of body surface body surface area, according to sex.*

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