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Article

Association between Anthropometric Measurements and Vascular Disease: A Cross Sectional Study

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Abstract: The aim of this article is to assess the most studied anthropometric measurements in a population of patients with vascular disease (VD) such as chronic venous disease (CVD), carotid stenosis (CS), abdominal aortic aneurysm (AAA), and peripheral artery disease (PAD). This is a cross sectional study that recruited consecutive patients with VD (CVD, CS, AAA, PAD) referred to Vascular Surgery Units of two hospitals in the period July 2019–March 2022. Several anthropometric measurements such as height, weight, body mass index (BMI), waist circumference, waist-to-BMI, waist-to-hip ratio (WHR), A Body Shape Index (ABSI), waist-to-stature ratio (WSR) were recorded. In a one-way ANOVA test, no statistical significance for all anthropometric variables were found, but the post hoc analysis performed with Tuckey test, show significant difference for height (p-value: 0.017) and WHR (p-value: 0.005) when compared AAA and CS groups with CVD, respectively. Height seems positively associated with AAA, and negatively associated with CVD. WHR seems positively associated with CS and negatively associated with CVD. Further studies are needed to clarify the role of anthropometric measures as independent predictors for vascular disease onset, progression, and response to treatments.

Keywords: anthropometry; vascular disease; abdominal aortic aneurysm; carotid artery stenosis; chronic venous disease; peripheral artery disease

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1. Introduction

Vascular disease (VD) affects the vascular system and can interfere with blood flow to or from the heart and organs. VD is widespread with an important prevalence, especially in the western world population, and is a leading cause of morbidity and mortality among affected patients, with important burden of social issues. The most common types of VD are Peripheral Artery Disease (PAD), abdominal aortic aneurysm (AAA), Chronic Venous Disease (CVD), and carotid stenosis (CS) [1,2] In fact, it is estimated that 30% of adult population suffers from PAD [3], 2% to 8% has AAA, [4] up to 80% suffers from CVD [5], and up to 5% has CS [6].

PAD of lower limbs is the narrowing or occlusion of the related arteries and is primarily caused by atherosclerosis. Intermittent claudication is the hallmark of PAD and when this condition worsens other symptoms such as rest pain and chronic wounds may appear [7].

AAA is a pathologic condition with progressive abdominal aortic dilatation of 3.0 cm or more that predisposes the aneurysmatic aorta to rupture with consequent need of emergency surgical intervention [8]

CVD refers to abnormal conditions related to or caused by the venous system of lower limbs that become incontinent and causes a multitude of problems from varicose veins to venous leg ulceration [5].

CS occurs when atherosclerotic plaques cause the narrowing of carotid arteries that deliver blood to the brain, increasing the risk of stroke [9].

Anthropometry refers to the systematic measurement of the physical characteristics of the human body and can help find out an individual's risk for development of noncommunicable diseases such cardiovascular diseases [10]. Some anthropometric parameters such as, body mass index (BMI), waist circumference, waist-to-BMI, waist-to-hip ratio (WHR), A Body Shape Index (ABSI), waist-to-stature ratio (WSR), have been related to vascular disease and related outcome [11–15].

Anthropometric measurements have been considered important factors for determining the health status of an individual, and they are also related to the social determinants of health (SDH) [16,17].

The aim of this article is to assess the most studied anthropometric measurements in a population of patients with several VD such as CVD, CS, AAA, and PAD.

2. Materials and Methods

2.1. Design

This study was designed as a cross sectional study to analyze the association between the anthropometric measures in vascular disease. The study was approved by the Institutional Review Board of Interuniversity Center of Phlebolymphology (CIFL) International Research and Educational Program in Clinical and Experimental Biotechnology (Approval number: E.R.ALL.2018.51.A.), and all patients gave written informed consent. The protocol was properly registered at a public trials' registry, www.clinicaltrial.gov (trial identifier NCT05472480) (accessed on 25 July 2022).

2.2. Participants

Consecutive patients with vascular diseases (CVD, CS, AAA, PAD) referred to Vascular Surgery Units of two hospitals (Mater Domini University Hospital of Catanzaro and the Federico II University Hospital of Naples) were observed in the period July 2019–March 2022.

The inclusion criteria were age > 18 years, both genders, being a patient with one type of vascular disease (among those investigated) at the time of the study.

Exclusion criteria were the presence of more than one contemporary vascular disease at the time of the study, to avoid overlapping of concomitant vascular disease, presence of any illiteracy, or psychiatric issues that may impair understanding or self-administration of the questionnaire, malignancies, presence of any genetic disease with influence on anthropometry (Turner syndrome, Klinefelter syndrome, etc.).

Patients were invited to participate in the study by the physician of the vascular unit, who explained the aims and the implications of the study and obtained the written informed consent. Demographic information and medical history were collected.

2.3. Vascular Diagnostics

Before inclusion, every patient was scanned with duplex ultrasonography of the following regions: carotid, abdominal aorta, veins, and arteries of lower limbs to exclude patients with more than one vascular disease. Patients with evidence of severe CS and/or AAA at duplex ultrasonography also underwent to computed tomography (CT) scan or magnetic resonance imaging (MRI). All VD groups were compared with a control group (CTRL) consisting of patients sent for suspected CVD, CS, PAD, or AAA, without finding such diseases at the duplex ultrasonography.

2.4. Measurements

Since it was necessary to study the anthropometric measures, different types of measurements were carried out. Height and weight were calculated with patients standing

without shoes and wearing light clothing. The BMI was quantified using the weight formula divided by the height squared (kg/m^2). Waist circumference was measured between the inferior costal margin and the iliac crest with patients in an upright position without heavy clothing, exhaling. ABSI was calculated as WC divided by BMI in power of 2/3 multiplied by height in power 1/2 (WC/(BMI2/3 × height1/2)). The circumference of the hips was recorded as the maximum circumference on the buttocks. The ratio of waist-to-hip ratio (WHR) was consequently calculated as a division of the two measures. The waist-to-stature ratio (WSR) was calculated as a division of the measures.

Demographics were collected for all patients with reference to the presence of some comorbidities such as coronary artery disease, diabetes mellitus, dyslipidemia, hypertension, chronic kidney disease, together with the status of being a current smoker.

2.5. Data Analysis

The statistical analysis was conducted with RStudio software, version 1.4.1106 © 2009–2021, Free Software Foundation, Boston, US. A descriptive analysis was performed to study the distributions of all variables of interest. Population variable (age) and all anthropometric characteristics (weight, age, BMI, waist circumference, WHR, WSR, ABSI) were analyzed by a one-way ANOVA test after verifying their normal distribution and homoscedasticity using the Saphiro–Wilk normality test and F test, respectively. Categorical variables (males, smokers, hypertension, diabetes, dyslipidemia, CAD, Chronic Kidney Disease) were assessed with sample tests for equality of proportions without continuity correction.

All anthropometric characteristics were also subjected to post hoc analysis using a Tuckey test to show any significant comparison.

Using the value corresponding to the 3rd quartile in the CVD group, all significant anthropometric characteristics were converted into categorical variables to quantify the statistical association. The rate of statistical association was calculated with Fisher's test.

To evaluate the adequacy of the sample, a two-sample proportional power calculation was evaluated using proportions similar to those used in Scicali's work (p1 = 0.50, p2 = 0.65, sig. level = 0.05, power = 0.70, N = 266) [18].

3. Results

Our study enrolled 250 patients, 155 males (62%), and 95 females (38%), 59 with CVD, 41 with CS, 49 with AAA, and 51 with PAD. The CTRL group consisted of 50 patients (Figure 1).

The mean age of patients is 65.2 years. Full demographics are reported in Table 1.

Considering the overall population of patients with vascular disease included, we found statistical significance for age, male sex, smoker status, hypertension, diabetes, and dyslipidemia.

Regarding CVD patients, 48/59 (81.35%) belonged to C2 stage of the Clinical-Etiology-Anatomy-Pathophysiology (CEAP) classification [19], 6/59 (10.16%) belonged to C3 stage, 3/59 (5.08%) belonged to C4 stage, and 2/59 patients (3.38%) belonged to C6 stage. Regarding CS patients, 34/41 (82.92%) have ≥60% carotid stenosis, and 7/41 (17.07%) have ≥30 < 60% stenosis. Regarding patients with AAA, 37/49 (75.51%) have an aortic diameter ranging from 5.75 to 7.2 cm, and 12/49 (24.49%) ranged from 3.5 to 4.5 cm. Regarding PAD patients, 11/51 (21.57%) belonged to category 3 of Rutherford classification [20], 31/51(60.78%) belonged to category 4, 5/51 (9.81%), belonged to category 5, and 4/51 (7.85%) belonged to category 6.

Anthropometric characteristics are reported in Table 2.

Table 1. Demographics (CTRL = control group; CVD = chronic venous disease; CS = carotid stenosis; AAA = abdominal aortic aneurysm; PAD = peripheral artery disease).

	Overall (N = 250)	**CTRL (n = 50/250)**	**CVD (n = 59/250)**	**CS (n = 41/250)**	**AAA (n = 49/250)**	**PAD (n = 51/250)**	***p*-Value (<0.05)**
Subject clinical characteristics							
Age (years)	65.2 ± 13.3	66 ± 12.8	60 ± 16.1	66.8 ± 11.9	67.7 ± 9.9	66.8 ± 13.3	0.086
	-	-	60 ± 16.1	-	67.7 ± 9.9	-	0.022
Males	155/250 (62%)	32/50 (64%)	22/59 (37.2%)	27/41 (65.8%)	40/49 (81.6%)	34/51 (66.6%)	<0.001
	-	32/50 (64%)	22/59 (37.2%)	-	-	-	0.009
	-	-	22/59 (37.2%)	27/41 (65.8%)	-	-	0.009
	-	-	22/59 (37.2%)	-	40/49 (81.6%)	-	<0.001
	-	-	22/59 (37.2%)	-	-	34/51 (66.6%)	0.003
Current smoker	76/250 (30.4%)	14/50 (28%)	9/59 (15.2%)	11/41 (26.8%)	25/49 (51%)	17/51 (33.3%)	0.002
	-	14/50 (28%)	-	-	25/49 (51%)	-	0.032
	-	-	9/59 (15.2%)	-	25/49 (51%)	-	<0.001
	-	-	9/59 (15.2%)	-	-	17/51 (33.3%)	0.045
	-	-	-	11/41 (26.8%)	25/49 (51%)	-	0.034
Hypertension	169/250 (67.6%)	38/50 (76%)	28/59 (47.4%)	30/41 (73.1%)	36/49 (73.4%)	37/51 (72.5%)	0.006
	-	38/50 (76%)	28/59 (47.4%)	-	-	-	0.004
	-	-	28/59 (47.4%)	-	-	37/51 (72.5%)	0.013
	-	-	28/59 (47.4%)	30/41 (73.1%)	-	-	0.018
	-	-	28/59 (47.4%)	-	36/49 (73.4%)	-	0.011
Diabetes	90/250 (36%)	17/50 (34%)	12/59 (20.3%)	16/41 (39%)	12/49 (24.4%)	33/51 (64.7%)	<0.001
	-	17/50 (34%)	-	-	-	33/51 (64.7%)	0.003
	-	-	12/59 (20.3%)	-	-	33/51 (64.7%)	<0.001
	-	-	-	16/41 (39%)	-	33/51 (64.7%)	0.024
					12/49 (24.4%)	33/51 (64.7%)	<0.001
Dyslipidemia	117/250 (46.8%)	23/50 (46%)	22/59 (37.2%)	25/41 (60.9%)	19/49 (38.7%)	28/51 (54.9%)	0.088
	-	-	22/59 (37.2%)	25/41 (60.9%)	-	-	0.033
Coronary Artery Disease	75/250 (30%)	14/50 (28%)	15/59 (25.4%)	13/41 (31.7%)	16/49 (32.6%)	17/51 (33.3%)	0.882
Chronic Kidney Disease	33/250 (13.2%)	3/50 (6%)	6/59 (10.1%)	6/41 (14.6%)	9/49 (18.3%)	9/51 (17.6%)	0.305

Table 2. Anthropometric characteristics.

	CTRL (n = 50/250)	**CVD (n = 59/250)**	**CS (n = 41/250)**	**AAA (n = 49/250)**	**PAD (n = 51/250)**	***p*-Value (<0.05)**
Anthropometric characteristics						
Weight (kg)						
- Overall (N = 250)	82.2 ± 18.7	79.9 ± 18.6	78.6 ± 14.3	80.4 ± 13.6	86.7 ± 24.6	0.232
- Males (n = 155/250)	81 ± 16.3	86.7 ± 16.7	80.6 ± 10.6	81.9 ± 13.6	85.2 ± 16.3	0.610
- Females (n = 95/250)	84.3 ± 22.5	75.8 ± 18.7	74.7 ± 19.4	73.5 ± 11.9	89.6 ± 25.8	0.351
Height (cm)						
- Overall (N = 250)	168 ± 8.4	165 ± 8.6	168.9 ± 7.7	169.8 ± 8.5	166.2 ± 7.4	0.621
	-	165 ± 8.6	-	169.8 ± 8.5	-	0.017
- Males (n = 155/250)	171.9 ± 6.1	173.4 ± 4.2	171.7 ± 6.3	172.7 ± 5.8	169.2 ± 6.7	0.107
- Females (n = 95/250)	161 ± 7.4	159.8 ± 6.2	163.5 ± 7.5	156.6 ± 5.5	160.3 ± 4.8	0.679
BMI (kg/m^2)						
- Overall (N = 250)	29.1 ± 6.8	29.1 ± 6.4	27.6 ± 5.6	27.9 ± 4.3	31.4 ± 9	0.267
- Males (n = 155/250)	27.3 ± 5	28.2 ± 5.7	27.4 ± 4.2	27.4 ± 3.9	29.6 ± 8.3	0.222
- Females (n = 95/250)	32.4 ± 8.4	29.6 ± 6.8	28 ± 7.8	29.9 ± 5.3	35 ± 9.6	0.244
Waist circumference (cm)						
- Overall (N = 250)	100.7 ± 19.3	102.4 ± 17.9	99.5 ± 13.4	98.3 ± 15	105.8 ± 22.5	0.446
- Males (n = 155/250)	96.8 ± 15.7	103.8 ± 16.1	99.5 ± 13	97.4 ± 14.8	102.3 ± 21.8	0.552
- Females (n = 95/250)	107.6 ± 23.3	101.6 ± 19.1	99.5 ± 14.9	102.3 ± 16	113 ± 22.8	0.321
WHR						
- Overall (N = 250)	0.932 ± 0.07	0.918 ± 0.09	0.978 ± 0.06	0.953 ± 0.08	0.950 ± 0.09	0.055
	-	0.918 ± 0.09	0.978 ± 0.06	-	-	0.005
- Males (n = 155/250)	0.955 ± 0.04	0.955 ± 0.11	0.984 ± 0.05	0.975 ± 0.05	0.956 ± 0.09	0.652
- Females (n = 95/250)	0.892 ± 0.09	0.895 ± 0.08	0.966 ± 0.08	0.854 ± 0.12	0.939 ± 0.08	0.192

Table 2. *Cont.*

	CTRL (n = 50/250)	**CVD (n = 59/250)**	**CS (n = 41/250)**	**AAA (n = 49/250)**	**PAD (n = 51/250)**	***p*-Value (<0.05)**
WSR						
- Overall (N = 250)	0.614 ± 0.149	0.638 ± 0.139	0.592 ± 0.101	0.593 ± 0.121	0.663 ± 0.202	0.437
- Males (n = 155/250)	0.572 ± 0.121	0.629 ± 0.148	0.586 ± 0.102	0.567 ± 0.09	0.643 ± 0.222	0.284
- Females (n = 95/250)	0.688 ± 0.169	0.643 ± 0.135	0.606 ± 0.102	0.710 ± 0.148	0.702 ± 0.154	0.413
ABSI						
- Overall (N = 250)	0.0818 ± 0.008	0.0836 ± 0.007	0.0837 ± 0.009	0.0815 ± 0.008	0.0826 ± 0.01	0.889
- Males (n = 155/250)	0.0810 ± 0.007	0.0837 ± 0.005	0.0831 ± 0.007	0.0809 ± 0.008	0.0823 ± 0.009	0.995
- Females (n = 95/250)	0.0831 ± 0.009	0.0835 ± 0.008	0.0849 ± 0.011	0.0843 ± 0.009	0.0833 ± 0.010	0.878

(CTRL = control group; CVD = Chronic Venous Disease; CS = carotid stenosis; AAA = abdominal aortic aneurysm; PAD = Peripheral Artery Disease; BMI = body mass index; WHR = waist to hip ratio; WSR = waist to stature ratio; ABSI = a body shape index).

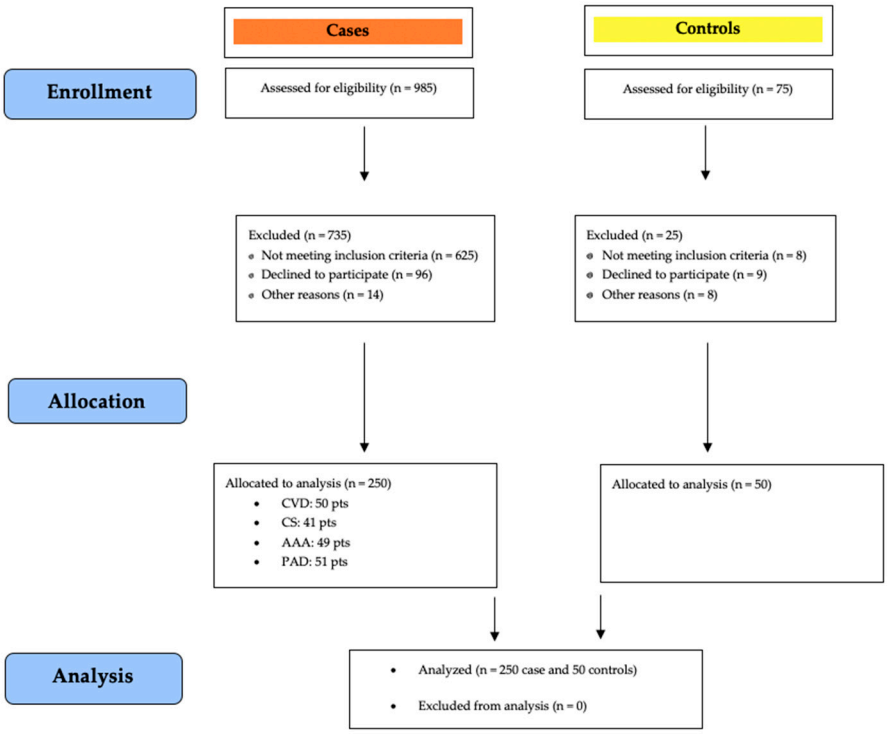

Figure 1. Flow chart for the inclusion of study subjects. (CVD = chronic venous disease; CS = carotid stenosis; AAA = abdominal aortic aneurysm; PAD = peripheral artery disease).

In a one-way ANOVA test, we found no statistical significance for all anthropometric variables. Otherwise, the post hoc analysis performed with Tuckey test, show significant difference for height (p-value: 0.017) and WHR (p-value: 0.005) when compared AAA and CS groups with CVD, respectively (Table 2).

To quantify the rate of statistical association in these significant comparisons, we used the value corresponding to the 3rd quartile of the variables height and WHR in the CVD group (170 cm and 0.980, respectively) as a threshold to convert them into categorical variables and obtain an estimate of the Odds Ratio.

Compared to the CVD group, the presence of AAA and severe CS is associated with a height $\geq$ 170 mm and values of WHR $\geq$ 0.980, respectively (Height $\geq$ 170 mm: CVD 23/59 (38.9%) vs. AAA 39/49 (61.2%), Odds Ratio 2.45, CI95% 1.06–5.79, p-value 0.033; WHR $\geq$ 0.980: CVD 13/59 (22%) vs. CS 21/41 (51.2%), Odds Ratio 3.66, CI95% 1.43–9.72, p-value 0.004) (Table 3).

Table 3. Quantification of the association for significant comparisons.

Height $\geq$ 170 mm [a]	Odds Ratio	95% CI	p-Value (<0.05)
CVD 23/59 (38.9%) vs. AAA 39/49 (61.2%)	2.45	[1.06; 5.79]	0.033
WHR $\geq$ 0.980 [a]			
CVD 13/59 (22%) vs. CS 21/41 (51.2%)	3.66	[1.43; 9.72]	0.004

([a] = value corresponding to the 3rd quartile in the CVD group; CI = confidence interval; CVD = chronic venous disease; AAA = abdominal aortic aneurysm; CS = carotid stenosis).

Histogram indicating distribution of Height and WHR in CVD, CS, AAA, and PAD are reported in Figure 2, respectively.

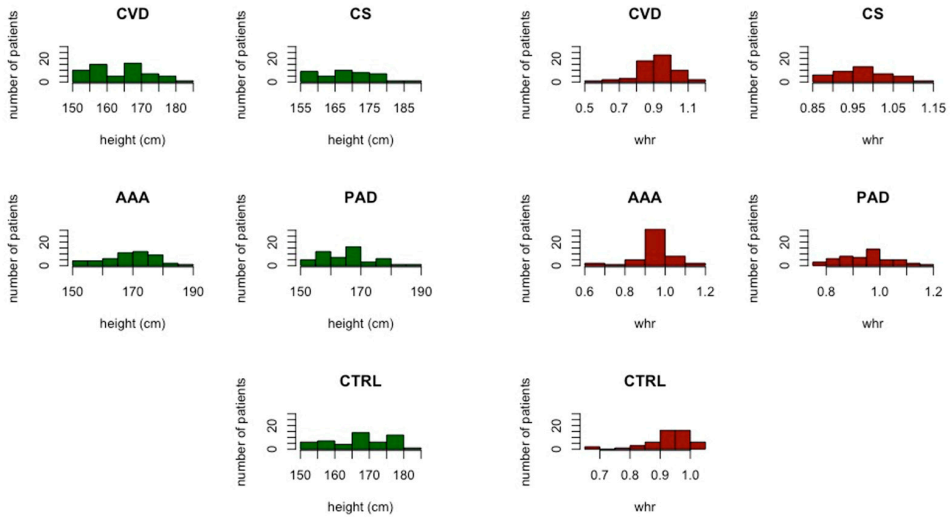

Figure 2. Distribution of Height and WHR in CVD, CS, AAA, and PAD. (WHR = waist-to-hip ratio).

4. Discussion

Paajanen TA et al. in a 2010 meta-analysis, evaluating 52 studies, found that shorter people had a 50% higher risk rates of coronary heart disease (CHD), and related morbidity and mortality, compared with taller individuals [21,22]. In our study, height seems to be negatively associated with CVD and positively associated with AAA. In fact, the shortest patients suffered from CVD, while the tallest patients had AAA.

In the current literature, height seems to be positively related to complications (i.e rupture) in AAA [23–25], and a taller height could probably elevate biomechanical wall stress on the arterial wall of the aorta. In fact, higher peak wall stress on the aortic wall has been recognized as a risk factor for the onset and progression of aortic aneurysmal disease [26,27]. Furthermore, the phenomenon of peaking (the aortic pressure wave that progresses distally along the aorta) increases its amplitude distally in the peripheral part of the aorta, and consequently, in taller individuals that have a longer aorta, the peripheral part of aorta (infrarenal segment) is more fragile, and then may become aneurysmatic [23].

In our study, AAA patients were the tallest among study groups. Adult height is a widely available and studied biomarker in several epidemiological studies among several human diseases. In fact, height reflects the interplay of genetic endowment and various life experiences and exposures, included social and psychological issues, that can predispose to a wide range of diseases, such as AAA [25].

Our study found that height was negatively associated with CVD. For height and CVD, no constant relationship was found in the current literature. In fact, while some studies showed positive correlations [28–31], other studies found no association [32–34]. Therefore, the issue of height and CVD needs further investigation also in the light of pathophysiological elements.

In our study, the lowest WHR was found in CVD patients, and this delineates a more gynoid aspect in these patients, and this can be easily explained with the major prevalence of this disease in females and in the hormonal effects of estrogens in the onset and progression of CVD [30]. The highest WHR value was associated with patients with CS, that is related to a more android aspect, and this is consistent with the current literature as this biomarker is related to peripheral atherosclerotic disease, especially in overweight patients. In fact, WHR was found to be associated with cardiovascular risk factors, CHD, vascular endothelial dysfunction, metabolic syndrome, adverse metabolic profiles, and a higher cardiovascular mortality, and worse cardiovascular disease outcomes. [18,22]. Further studies are needed to determine the clinical use in atherosclerotic arterial disease.

In our study, no differences were found between groups for BMI, WSR, and ABSI, and therefore these measurements that do not offer effective elements in differentiating vascular disease in our study population.

Our study has several limits. Primarily, the cross-sectional design itself is an important limiting factor that exposes the risk of incidence-prevalence bias (also known as Neyman bias). As result, some associations may be lost because several cases have not had enough time to develop a VD or have too mild of a VD to be detected at the time of the study.

Other limits include the small number of participants, the observational nature, and the open label structure, and all of this does not allow to draw definitive conclusions. Nevertheless, anthropometric evaluation represents a less resource-consuming and non-invasive assessment to determine size, proportions, and composition of the body to be related to a wide range of disease including cardiovascular and peripheral vascular disease [35]. Based on these findings, further studies are needed to clarify the role of anthropometric measures as independent predictors for vascular disease onset, progression, and response to treatments.

Author Contributions: Conceptualization, D.C. and R.S.; methodology, D.C., M.A., F.I., N.I., A.P., U.M.B. and R.S.; software, D.C., N.I. and R.S.; validation, D.C., M.A., F.I., N.I., A.P., U.M.B. and R.S.; formal analysis, D.C., N.I. and R.S.; investigation, D.C., M.A., F.I., N.I., A.P., U.M.B. and R.S.; data curation, D.C., N.I. and R.S.; writing—original draft preparation, D.C., M.A., F.I., N.I., A.P., U.M.B. and R.S.; writing—review and editing, D.C., M.A., U.M.B. and R.S.; visualization, D.C., M.A, F.I., N.I., A.P., U.M.B. and R.S.; supervision, D.C. and R.S. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: All patients gave written informed consent.

Data Availability Statement: All data generated or analyzed during this study are included in this published article.

Conflicts of Interest: The authors declare no conflict of interest.

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