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Relationship of atherosclerosis and atrial fibrillation predictors with body composition in obese individuals

Asli Kurtar Mansiroglu[1], Tugba Disikirik[2], Osman Yasin Yalcin[3], Buket Busra Icin[4], Esra Nur Ademoglu Dilekci[5]

[1]*Department of Cardiology, Kırklareli University Hospital, Kırklareli, Türkiye*
[2]*Department of Cardiology, Bolu Abant Izzet Baysal University Hospital, Bolu, Türkiye*
[3]*Department of Cardiology, Gümüşhane Kelkit Hospital, Gümüşhane, Türkiye*
[4]*Department of Internal Medicine, Bou Abant Izzet Baysal University Hospital, Bolu, Türkiye*
[5]*Department of Endocrinology and Metabolic Diseases, Medicana Hospital, İstanbul, Türkiye*

ABSTRACT

Aim: To investigate the markers that may predict both atrial fibrillation (AF) and atherosclerosis in obese patients.

Method: This study was conducted on 108 participants (54 women and 54 men) with a body mass index (i.e., BMI) of at least 30. In addition to the electrocardiogram (ECG) and transthoracic echocardiography (TTE) findings, we also analyzed the findings of body composition by means of the bioelectric impedance analysis method using the Tanita MC 780 MA analyzer in all participants.

Results: We found that the minimal area of the left atrium (LA) had a very strong (r = 0.978, p = 0.022) correlation with visceral adiposity and a weak positive correlation with waist circumference. Aortic stiffness had a weak positive correlation with visceral adiposity ratio (p = 0.022) and fat mass (r = 0.323, p = 0.001). The diameter of LA had weak positive correlations with visceral adiposity (p = 0.018), waist circumference (r = 0.336, p < 0.001), fat-free mass (r = 0.323, p = 0.001), muscle mass (r = 0.324, p = 0.001), liquid mass (r = 0.323, p = 0.001) and metabolic age (r = 0.364, p < 0.001). Again, we found weak positive correlations of epicardial fat tissue with visceral adiposity (r = 0.459, p = 0.018) and metabolic age (r = 0.350, p < 0.001).

Conclusions: In our study, it has been noted that obese patients may have different levels of risk for AF and atherosclerosis, and there may be a more risky subgroup in which the distribution of some anthropometric and body tissue components differs.

Key words: Atrial fibrillation, atherosclerosis**,** obesity, body composition, Tanita.

✉ *Dr. Asli Kurtar Mansiroglu,*
Kırklareli University Hospital, Department of Cardiology; Ayla Mahallesi, Çamlık Caddesi No: 49 Kırklareli, Türkiye
E-mail: dr.asli.kurtar@gmail.com
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Introduction

Obesity is a growing health problem worldwide [1]. According to the criteria established by the World Health Organization (WHO), adult individuals are categorized as obese when they have a body mass index (BMI) of at least 30 [2]. Atrial fibrillation (AF) is the most common arrhythmia characterized by a constant rhythm disturbance in the heart [3]. The incidence of AF is expected to increase in the future because of increased predisposing factors such as obesity and prolonged average life span of a community,

increased number of cardiac interventions, and increased life expectancy in patients with myocardial infarction and heart failure [3]. Both obesity and the resulting conditions such as hypertension and insulin resistance are risk factors for atherosclerosis and coronary artery disease [4].

As noted by the WHO, BMI is not a direct indicator of body tissue distribution. Accordingly, the BMI of a first-class bodybuilder can fall within the obesity category, despite the low amount of body fat and high muscle mass [5]. For this reason, the literature focuses on studies investigating the relationship of body tissue distribution with diseases [6].

In the literature, electrocardiography, and echocardiography parameters screen for cardiovascular risk. The development of the non-invasive detection of atherosclerosis and atrial fibrillation is significant in preventing cardiovascular problems.

Therefore, in this study, we aimed to investigate the relationship of body tissue distribution analyses with atherosclerosis and atrial fibrillation risk predictors determined by 12-lead electrocardiograms (ECG) and transthoracic echocardiography (TTE) in patients with obesity.

Materials and methods

This single-center study was conducted on 108 obese patients with an age distribution of > 18 and < 75 years who applied to the internal medicine outpatient clinic between January 2021 and May 2021. Approval for the study was obtained from the ethics committee of Bolu Abant İzzet Baysal University. (Date: 27.04.2021, No.2021/94). Demographic characteristics of patients were obtained from their anamnesis. In addition to anthropometric exams, the bioelectric impedance of body compositions was measured using the Tanita MC 780 MA device in all patients. Standard ECG and TTE results were assessed simultaneously. The patients were evaluated once in the outpatient clinic without follow-up.

Hypertension (HT) was diagnosed in those with a blood pressure of 140/90 mmHg or who were currently taking antihypertensive medication. Diabetes mellitus (DM) was defined by any current use of diabetes medications, a fasting blood glucose level greater than 126 mg/dl, or HbA1c 7. The diagnosis of hyperlipidemia (HL) was based on a total cholesterol level ≥ 200 mg/dL, LDL-c level ≥ 130 mg/dL, or any use of cholesterol-lowering medication. A current smoker was defined as an individual with a current or past history of tobacco use of more than 10 packs per year. An individual with a family history of coronary artery disease (CAD) was defined as having one or more close relatives who had been diagnosed with the disease before the age of 55 for men and 65 for women. Alcohol usage was defined as the intake of 2 drinks or fewer a day for men and 1 drink or fewer a day for women. Physical activity was defined as performing moderate-intensity exercise activity for at least 30 minutes on a minimum of 2-3 days/week.

We excluded those aged <18 and >75 years and with a history of the following conditions: coronary artery disease, left ventricular systolic dysfunction (EF < 50%), moderate to severe valvular disease, congenital heart disease, atrioventricular conduction abnormality, atrial fibrillation, moderate to severe kidney or liver disease, thyroid disease, electrolytic imbalance, and poor acoustic echocardiography window.

The study protocol was approved by the Local Ethics Committee. Informed consent was obtained from each subject before participation.

Echocardiography evaluation

A 4-Mhz transducer of Vivid S6 (GE Vingmed, N-3191, Horten-Norway) was used to perform

the required echocardiography procedures. For this purpose, we measured systolic (SBP) and diastolic (DBP) blood pressures, and calculated the pulse pressure (PP). A cardiologist obtained TTE using continuous ECG monitoring with the participants in the left lateral position.

Aortic diameter change, aortic strain, aortic distensibility, and aortic stiffness index were used as predictors of atherosclerosis. The diameter and area of the left atrium (LA), P-dispersion, Pa-TDI (septal and lateral), and epicardial fat were used as AF predictors.

The ascending aorta was measured by M-Mod echocardiography using a parasternal long-axis view at 3 cm above the aortic valve level. We measured the systolic (AoSD) and diastolic (AoDD) diameters at the maximal anterior motion of the aorta and the onset of the QRS complex, respectively, and recorded them concurrently. The mean systolic and diastolic values were obtained after three consecutive measurements.

The aortic stiffness parameters were calculated using the following equations [7]:

(1) Aortic diameter change (ADC): AoSD - AoDD

(2) Aortic strain (AS) %: ADC/AoDD

(3) Aortic distensibility (cm2 dyn-1 10 - 3): 2 AS/PP

(4) Aortic stiffness index (ASI): (SBP/DBP) / [(ADC)/AoDD].

The left atrial diameter (LAD) was measured using M-mode tracings from the middle of the mitral annular plane to the posterior wall. The maximum left atrium area (LAA) was assessed from the apical four-chamber view at the end-ventricular systole, planimetered with the inferior LA border defined as the plane of the mitral annular plane, excluding the confluence of the pulmonary veins and the LA appendage [8]. The minimum LAA was assessed from a four chamber view at the end-ventricular diastole [8].

Epicardial fat is defined as a visceral fat deposit between the myocardial surface and the visceral layer of the pericardium. Epicardial fat thickness is identified as an echo-free space between the outer wall of the myocardium and the visceral layer of the pericardium in the parasternal longaxis view and measured during end-systole at the point on the free wall of the right ventricle along the midline of the ultrasound beam, with the best effort to be perpendicular to the aortic annulus, used as an anatomic landmark [9].

Electrocardiogram and measurement of indices

Standard 12-lead resting ECG recordings were obtained using Nihon Kohen Cardiofax ECG-1950 VET at a paper speed of 25 mm/s and amplitude of 10 mm/mV. All patients were found to be in sinus rhythm. Heart rate beat was noted from 12-lead ECG. P-wave dispersion is calculated by subtracting the minimum P-wave duration from the maximum one [10].

PA-TDI septal/lateral was defined as the time interval from the onset of p-wave in lead II of the ECG on echocardiography images to the peak a′-wave of the septal mitral valve annulus or the peak a′-wave of the lateral mitral valve annulus [11].

Anthropometric measurements

The weight of the participants was measured using a digital scale (Soehnle, Murrhardt, Germany), and their height was measured while standing without shoes.

BMI was calculated using the formula: weight (kg)/ height^2 (m^2). Body surface area was calculated based on the Du Bois Method as follows: Body Surface Area (BSA) = 0.007184 x (Height (m)$^{0.725}$) x (Weight (kg)$^{0.425}$) [12].

Waist circumference was measured at the narrowest area between the lower rib and the iliac crest (natural waist), or, in the case of an indeterminate lumbar narrowing, at the midpoint

between the lower rib and the iliac crest. Hip circumference was measured over the widest part of the hips. Waist Circumference Index (WCI) was calculated by dividing the waist circumference by the BSA value.

Body composition can be estimated by the bioelectrical impedance analysis (BIA) method, where the resistance to the flow of an electric current is measured. BIA is a reliable, noninvasive, and easy-to-use method for estimating body composition parameters. In this study, we used the Tanita MC 780 MA device as a body composition analyzer. As a result of our measurements, we were able to reach the following variables: body mass (kg), BMI, metabolic age, basal metabolic rate (kcal), fat mass and percentage (kg, %), lean body mass and percentage (kg, %), muscle mass and percentage (kg, %), total body water and percentage (kg, %), and visceral fat.

The fat mass index (FMI) and the fat-free mass index (FFMI) were calculated by dividing the total fat mass by the BSA value, and dividing the total lean mass by the BSA value, respectively.

Statistical analysis

Analyses were performed using IBM SPSS v.21 Statistical Package Software for Windows (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to define both numerical (mean, median, standard deviation, minimum and maximum values) and categorical (number and percentage values) variables. The Kolmogorov-Smirnov test and graphs (box-line graph and histogram) were used for the normality assumption. The relationship between atherosclerotic predictors, AF predictors, and body composition was analyzed using Pearson or Spearman correlation coefficients.

P-values < 0.05 were taken to be statistically significant.

Results

The demographic and clinical variables of the patients are presented in Table 1.

Table 2 shows the atherosclerotic and AF predictors detected by echocardiography and electrocardiography.

Table 1. Demographic variables of the study population (n=108).

Parameters		**No (%)**
Sex	Female Male	54 (50.0) 54 (50.0)
Hypertension	No Yes	75 (69.4) 33 (30.6)
Diabetes Mellitus	No Yes	85 (78.7) 23 (21.3)
Hyperlipidemia	No Yes	98 (90.7) 10 (9.3)
Family History For CAD	No Yes	73 (67.6) 35 (32.4)
Smoking	No Yes	74 (68.5) 34 (31.5)
Alcohol	No Yes	95 (88.0) 13 (12.0)
Physical Activity	No Yes	102 (94.4) 6 (5.6)
	Mean ± SD	**Min. – Max.**
Age	44.41 ± 13.96	18 – 75
Height (cm)	165.56 ± 11.04	144 – 192
Weight (kg)	100.34 ± 16.04	64 – 147
BMI (kg/m^2)	36.92 ± 5.23	30 – 59.8
BSA (m^2)	2.08 ± 0.21	1.59 – 2.60
SBP (mmHg)	134.88 ± 17.25	100 – 190
DBP (mmHg)	82.17 ± 12.13	50 – 120
PP (mmHg)	52.81 ± 13.82	20 – 90
Heart Beat Rate (bpm)	83.10 ± 14.61	54 – 126

CAD: coronary artery disease; BMI: body mass index; BSA: body surface area; SBP: systolic blood pressure; DBP: diastolic blood pressure; PP: pulse pressure; bpm: beat per minute.

Table 3 shows anthropometric and bioelectrical impedance-derived parameters measured by the Tanita device for body composition.

Correlation analyses revealed the highest positive correlation between visceral adiposity and aortic stiffness (r = 0.448, p = 0.022) and between fat mass and aortic stiffness (r = 0.323, p = 0.001) among the predictors of atherosclerosis.

As for the predictors of atrial fibrillation, the LA value had a weak positive correlation with visceral adiposity (r = 0.462, p = 0.018), waist circumference (r = 0.336, p < 0.001), fat-free mass (r = 0.323, p = 0.001), muscle mass (r = 0.324, p = 0.001), liquid mass (r = 0.323, p = 0.001), and metabolic age (r = 0.364, p < 0.001). The minimum area of LA had a weak positive correlation with the waist circumference (r = 0.388, p = 0.061) and a very strong correlation with the visceral adiposity (r = 0.978, p = 0.022). We found the highest (and weak positive) correlation of epicardial fat with visceral adiposity (r = 0.459, p = 0.018). Likewise, there was a weak positive correlation between epicardial fat and metabolic age (r = 0.350, p < 0.001). No significant correlation was found between p-dispersion and any other anthropometric or bioelectrical impedance-derived parameters.

From the relationship between other echocardiography parameters and body tissue analyses, we found a weak positive correlation of the aortic root with fat-free mass (r = 0.430, p < 0.001), muscle mass (r = 0.429, p < 0.001), liquid mass (r = 0.387, p < 0.001), and FFMI (r = 0.356, p < 0.001) (Table 4).

Table 2. Patient characteristics of atherosclerotic and atrial fibrillation predictors.

Parameters	Mean	SD	Median	Min. – Max.
Aortic Systolic Diameter (cm)	3.09	0.45	2.90	2.04 – 4.30
Aortic Diastolic Diameter (cm)	2.84	0.46	2.63	1.74 – 4.10
Aortic Diameter Change (cm)	0.257	0.139	0.250	0.03 – 0.70
Aortic Strain	9.522	5.863	8.632	0.96 – 29.89
Aortic Stiffness	7.481	8.654	4.413	1.20 – 55.27
Aortic Distensibility	0.004	0.003	0.003	0.000 – 0.013
P Dispertion	56.54	13.18	55.6	32.8 – 96.4
Pa-TDI (septal)	19.55	15.94	18.0	0.0 – 99.0
Pa-TDI (lateral)	21.90	16.94	19.0	0.0 – 106.0
Left Atrium (cm)	3.56	0.40	3.55	2.60 – 4.88
LA maximum area	19.50	2.92	19.90	15.10 – 25.80
LA minimum area	12.23	3.03	11.35	7.84 – 21.0
Epicardial fat	0.55	0.17	0.54	0.19 – 0.43

SD: standard deviation; LA: left atrium.

Table 3. Anthropometric and bioelectrical impedance-derived parameters for body composition of the patients.

Parameters	n	Mean	SD	Median	Min – Max.
Waist Circumference (cm)	108	117.27	11.99	116.0	95.0 – 149.0
Hip Circumference (cm)	108	119.44	9.86	120.0	101.0 – 144.0
Waist to hip Ratio	108	0.985	0.099	1.004	0.76 – 1.28
Lean Body Mass (kg)	108	61.83	12.69	58.65	42.5 – 95.4
Lean Body Percentage (%)	108	61.16	7.73	58.89	42.78 – 77.22
Muscle mass (kg)	108	58.73	12.13	55.70	40.3 – 90.8
Muscle Percentage (%)	108	58.18	7.33	57.24	40.58 – 73.42
Fat Mass (kg)	108	39.37	10.68	39.55	19.8 – 72.9
Fat Percentage (%)	108	38.75	7.77	40.11	22.78 – 57.22
Body Water Mass (kg)	108	44.88	9.41	43.50	29.7 – 67.1
Body Water Percentage (%)	108	44.33	5.31	45.23	31.71 – 54.89
Metabolic Age	108	57.11	38.18	53.50	18.0 – 84.0
Basal Metabolism Rate (kcal)	108	1.83	0.26	1.78	1.41 – 2.80
Visceral fat level	26	14.81	6.07	14.0	7.0 – 30.0
WCI (cm/m^2)	108	56.51	5.56	55.69	42.97 – 70.95
FMI (kg/m^2)	108	18.88	4.70	18.73	9.71 – 34.88
FFMI (kg/m^2)	108	29.38	3.66	28.91	21.91 – 36.83
Waist to Height Ratio	108	0.71	0.09	0.71	0.57 – 1.09

WCI: Waist Circumference Index; FMI: fat mass index; FFMI: fat-free mass index.

Discussion

In this study, we investigated the relationship between body composition and several parameters that could be considered predictors of atherosclerosis and atrial fibrillation in obese patients. Among atherosclerotic predictors, aortic stiffness had a weak correlation with visceral adiposity and fat mass. However, among AF predictors, epicardial fat and minimum LA area had similar correlations with LA diameter and visceral fat, respectively, and were found to have weak associations with several parameters as well. Previous studies have shown the association of between obesity with hypertension, hyperlipidemia, diabetes mellitus, obstructive sleep apnea syndrome, coronary artery disease, heart failure, cardiac arrhythmias, and sudden cardiac death [13]. Studies have focused on new clinical measurements, since BMI does not provide

Table 4. Correlations between atherosclerosis and atrial fibrillation predictors with body obese individuals.

Parameters		Visceral adiposity	Fat mass	Waist circumference	Fat- free mass	Muscle mass	Liquid mass	Metabolic age	FFMI
Aortic stiffness	r	0.448	0.323	0.216	0.109	0.109	0.120	0.093	0.052
	p	0.022	0.001	0.025	0.262	0.263	0.218	0.339	0.594
LA value	r	0.462	0.165	0.336	0.323	0.324	0.323	0.364	0.044
	p	0.018	0.088	<0.001	0.001	0.001	0.001	<0.001	0.651
Minimum area of LA	r	0.978	0.242	0.338	0.068	0.080	0.238	0.230	0.095
	p	0.022	0.254	0.061	0.753	0.710	0.263	0.279	0.659
Epicardial fat	r	0.459	0.143	0.287	0.028	0.029	0.039	0.350	0.013
	p	0.018	0.141	0.003	0.771	0.768	0.685	<0.001	0.896
Aortic root	r	0.140	0.083	0.290	0.430	0.429	0.387	0.131	0.356
	p	0.496	0.391	0.002	<0.001	<0.001	<0.001	0.175	<0.001

LA: left atrium, FFMI: fat-free mass index.

information about the distribution of body tissues. The most important parameters include waist circumference, waist/hip ratio, and waist/height ratio parameters, particularly giving an idea about central or abdominal obesity.

Abdominal circumference greater than 102 cm in men and 88 cm in women [14], or a waist/hip ratio greater than 0.9 in men and 0.85 in women, indicates central obesity [15]. Márcia Mara Corrêa et al. drew attention to the point in their studies with the sentence, "Your waist circumference should be less than half your height" [16].

In a publication in which thirty reviews and meta-analyses were scanned, AF development was correlated with BMI in twenty five studies with waist circumference in five studies with hip circumference in three studies with the waist-to-hip ratio in four studies, and total fat mass in the other four studies [6].

Although the LA dimension was underestimated in the parasternal long-axis view using the method by which the anteroposterior diameter can be measured [17], we found in our study that LA diameter was correlated, albeit weakly, with many anthropometric and body composition measurements.

The increase in the maximal and minimal LA areas has been associated with an increased risk of developing AF, stroke, heart failure, and mortality [18]. Although the American Society of Echocardiography recommends the use of left atrial volume as the gold standard for left atrium measurement [19], measuring the left atrial area may both be easier and provides more advantages than measuring the left atrial size in our daily practice. We found in our study that the minimum LA area had a very strong correlation with visceral adiposity, but a weak positive correlation with the waist circumference.

In light of our literature review, we found out epicardial fatty tissue (EFT) secretes active metabolic factors, angiogenic factors, growth and remodeling factors, adipocytokines, inflammatory cytokines and chemokines and various interleukins, plasminogen activator inhibitor-1, tumor necrosis factor alpha, monocyte chemotactic protein 1, chemokine ligands, adrenomedullin, and phospholipase A2 [20]. Although the mechanism by which EFT induces the susceptibility to AF has not yet been clarified, it is assumed that many active molecules secreted may cause LA hypertrophy, fibrosis, and

arrhythmogenic substrate [21]. This study demonstrates the relationship of EFT with visceral adiposity and metabolic age in obese patients.

Aortic stiffness is an individual yet powerful predictor of cardiovascular disease in obese people [22]. Although considered a precursor of atherosclerosis, aortic stiffness was weakly associated with visceral adiposity and fat mass in our study.

A search of the literature revealed several studies addressing the level of arterial stiffness and body composition analyses in patients who underwent kidney and liver transplantation [23, 24]. The effects of different types of exercise on aortic stiffness and body tissue distribution were also investigated by Saran et al. [25]; however, this study is the first to analyze the relationship of aortic stiffness with these two parameters.

In our study, it has been noted that obese patients may have different levels of risk for AF and atherosclerosis, and there may be a more risky subgroup in which the distribution of some anthropometric and body tissue components differs. Despite the advances in treatment modalities, both obesity and related diseases are among the most important causes of morbidity and mortality worldwide. Supporting our study results with larger-scale and long-term follow-up studies may shed light on some predictors that may be the primary target in the struggle against obesity. The main limitation of our study is that it was conducted in a single center. Another limitation is that patients do not have long-term follow-up, and therefore the results reflected in daily practice prevent interpretation. The presence of exclusion criteria prevents us from generalizing the results to all obese patients.

Conclusion

Certain risk predictors of atherosclerosis and atrial fibrillation identified in our study may enable early diagnosis and treatment of subclinical conditions and thus prevention of cardiovascular events in obese patients. Routine cardiovascular examination of obese patients may allow us to assess these parameters and to monitor patients for the development of prospective atherosclerosis and atrial fibrillation. Larger-scale studies with long-term follow-ups are needed to reflect the study results in our daily practice.

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References

[1] Breda J, Jewell J, Keller A. The importance of the world health organization sugar guidelines for dental health and obesity prevention. Caries Res. 2019;53(2):149-52.

[2] Lee E. The world health organization's global strategy on diet, physical activity, and health: Turning strategy into action. Food Drug Law J. 2005;60(4):569-601.

[3] Lloyd-Jones DM, Wang TJ, Leip EP, et al. Lifetime risk for development of atrial fibrillation: the Framingham Heart Study. Circulation. 2004;110(9):1042-46.
[4] Csige I, Ujvárosy D, Szabó Z, et al. The impact of obesity on the cardiovascular system. J Diabetes Res. 2018;2018:3407306.
[5] Fenger-Grøn M, Vinter N, Frost L. Body mass and atrial fibrillation risk: Status of the epidemiology concerning the influence of fat versus lean body mass. Trends Cardiovasc Med. 2020;30(4):205-11.
[6] Aune D, Sen A, Schlesinger S, et al. Body mass index, abdominal fatness, fat mass and the risk of atrial fibrillation: a systematic review and dose–response meta-analysis of prospective studies. Eur J Epidemiol. 2017;32(3):181-92.
[7] Lacombe F, Dart A, Dewar E, et al. Arterial elastic properties in man: a comparison of echo-Doppler indices of aortic stiffness. Eur Heart J. 1992;13(8):1040-45.
[8] Tsang TS, Abhayaratna WP, Barnes ME, et al. Prediction of cardiovascular outcomes with left atrial size: is volume superior to area or diameter? J Am Coll Cardiol. 2006;47(5):1018-23.
[9] Iacobellis G, Assael F, Ribaudo MC, et al. Epicardial fat from echocardiography: a new method for visceral adipose tissue prediction. Obes Res. 2003;11(2):304-10.
[10] Okutucu S, Aytemir K, Oto A. P-wave dispersion: what we know till now? JRSM Cardiovasc Dis. 2016;5:2048004016639443.
[11] Sieweke J-T, Pfeffer TJ, Biber S, et al. miR−21 and NT-proBNP Correlate with Echocardiographic Parameters of Atrial Dysfunction and Predict Atrial Fibrillation. J Clin Med. 2020;9(4):1118.
[12] Burton RF. Estimating body surface area from mass and height: theory and the formula of Du Bois and Du Bois. Ann Hum Biol. 2008;35(2):170-84.
[13] Poirier P, Giles TD, Bray GA, et al. Obesity and cardiovascular disease: pathophysiology, evaluation, and effect of weight loss: an update of the 1997 American Heart Association Scientific Statement on Obesity and Heart Disease from the Obesity Committee of the Council on Nutrition, Physical Activity, and Metabolism. Circulation. 2006;113(6):898-918.
[14] Yusuf S, Hawken S, Ôunpuu S, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. The lancet. 2004;364(9438):937-52.
[15] Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. Int J Food Sci Nutr. 2005;56(5):303-7.
[16] Corrêa MM, Facchini LA, Thumé E, et al. The ability of waist-to-height ratio to identify health risk. Rev Saude Publica. 2019;53.
[17] Lavie CJ, Pandey A, Lau DH, et al. Obesity and atrial fibrillation prevalence, pathogenesis, and prognosis: effects of weight loss and exercise. J Am Coll Cardiol. 2017;70(16):2022-35.
[18] Abhayaratna WP, Seward JB, Appleton CP, et al. Left atrial size: physiologic determinants and clinical applications. J Am Coll Cardiol.2006;47(12):2357-63.
[19] Lang RM, Bierig M, Devereux RB, et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European

Society of Cardiology. J Am Soc Echocardiogr. 2005;18(12):1440-63.

[20] Hatem SN, Redheuil A, Gandjbakhch E. Cardiac adipose tissue and atrial fibrillation: the perils of adiposity. Cardiovasc Res. 2016;109(4):502-9.

[21] Venteclef N, Guglielmi V, Balse E, et al. Human epicardial adipose tissue induces fibrosis of the atrial myocardium through the secretion of adipo-fibrokines. Eur Heart J. 2015;36(13):795-805.

[22] Aroor AR, Jia G, Sowers JR. Cellular mechanisms underlying obesity-induced arterial stiffness. Am J Physiol Regul Integr Comp Physiol. 2018;314(3):R387-R98.

[23] Saran M, Wyzgał J, Pacek A, editors. Comparative analysis of arterial stiffness and body composition in early and late periods after kidney transplantation. Transplant Proc.; 2018: Elsevier.

[24] Szewc U, Wyzgał J, editors. Assessment of arterial stiffness and body composition in stable liver transplant recipients. Transplant Proc.; 2018: Elsevier.

[25] Kujawski S, Kujawska A, Gajos M, et al. Effects of 3-months sitting callisthenic balance and resistance exercise on aerobic capacity, aortic stiffness and body composition in healthy older participants. Randomized Controlled Trial. Exp Gerontol. 2018;108:125-30.