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Original Articles

Correlations between Some Cardiac and Anthropometric Parameters in Male Patients from South Bulgaria with Arterial Hypertension

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This study aims to evaluate the relationships between anthropometric parameters and echocardiographic markers of left ventricular structure and geometry in Bulgarian men with arterial hypertension. Anthropometric indices reflecting overall and central adiposity were assessed, and transthoracic echocardiography was used to measure interventricular septal thickness, posterior wall thickness and left ventricular internal diameter in diastole. Left ventricular mass, left ventricular mass index, and relative wall thickness were calculated. Correlation analysis demonstrated significant positive associations between most anthropometric measurements: particularly body weight, body mass index, waist and hip circumference, and body surface area as well as echocardiographic indices of left ventricular wall thickness, chamber dimensions, and myocardial mass. Waist-to-height ratio and body roundness index were also significantly associated with several echocardiographic parameters. These findings indicate that anthropometric parameters, especially those reflecting overall and central adiposity, are closely associated with left ventricular remodeling in men with arterial hypertension.

Key words: Bulgarians, arterial hypertension, cardiac measurements, anthropological parameters, correlations

Introduction

Arterial hypertension is one of the most prevalent cardiovascular disorders worldwide and remains a leading risk factor for cardiovascular morbidity and mortality, contributing substantially to the development of heart failure, ischemic heart disease, and stroke [15]. Sustained elevation of arterial pressure imposes chronic hemodynamic overload on the myocardium, leading to structural and geometric alterations of the left ventricle collectively described as left ventricular remodeling [5]. These alterations include increased myocardial wall thickness, left ventricular hypertrophy, chamber dilatation, and changes in ventricular geometry, all of which have been known to have independent prognostic significance [11].

Echocardiography is the preferred non-invasive imaging modality for the assessment of left ventricular structure and geometry, allowing accurate quantification of interventricular septal thickness, posterior wall thickness, left ventricular internal diameter from which left ventricular mass, left ventricular mass index, and relative wall thickness can be calculated [9]. Increased left ventricular mass and abnormal ventricular geometry have been consistently associated with adverse cardiovascular outcomes, independent of blood pressure levels and other common risk factors [4].

Anthropometric characteristics have been increasingly recognized as important determinants of left ventricular remodeling in patients with arterial hypertension [14]. Traditional measures such as body weight, body mass index, waist circumference, and hip circumference reflect overall and regional adiposity and have been shown to correlate with left ventricular mass and myocardial wall thickness in hypertensive populations [7]. Excess adiposity contributes to cardiac structural changes through complex mechanisms involving increased circulating blood volume, neurohormonal activation, insulin resistance, and chronic low-grade inflammation [10].

In recent years, novel anthropometric indices, including waist-to-height ratio, body roundness index, body surface area, and a body shape index, have been proposed as alternative markers of cardiometabolic risk that may better capture the effects of body fat distribution than traditional indices [8]. However, the associations between these newer anthropometric measures and echocardiographic markers of left ventricular remodeling remain insufficiently studied, particularly in patients with established arterial hypertension [1]. Moreover, available data comparing the relative predictive value of classical and novel anthropometric indices for specific echocardiographic parameters are limited and inconsistent [6].

Furthermore, sex-related differences influence the relationship between anthropometry and cardiac remodeling. Men with arterial hypertension more frequently exhibit increased left ventricular mass and larger chamber dimensions compared with women at similar blood pressure levels [13]. These differences may be attributed to variations in body composition, fat distribution, and hormonal milieu, as well as differences in myocardial adaptive responses to pressure overload [12]. Considerable number of hypertension-focused studies have demonstrated that left ventricular hypertrophy is highly prevalent in hypertensive men and can be important prognostic predictor [2].

Identifying anthropometric parameters that are most strongly associated with left ventricular wall thickness, chamber dimensions, mass, and geometry may improve early risk stratification and facilitate the individualized management of patients with arterial hypertension [3].

The present study **aims** to evaluate the relationship between anthropometric parameters and echocardiographic markers of left ventricular structure and geometry in Bulgarian men with arterial hypertension.

Materials and Methods

The study included 60 male patients with arterial hypertension. The research was conducted at medical center "Tonus" in the city ot Pazardjik, Bulgaria. ***The inclusion criteria*** for the patients were Bulgarian origin, age between 40 and 70 years, a history of arterial hypertension (Systolic blood pressure ≥ 140 mmHg and/or Diastolic blood pressure ≥ 90 mmHg measured on at least two separate occasions) of at least five years duration, and good pharmacological blood pressure control. Patients with a previous history of acute coronary syndrome (ACS) were ***excluded from the study***. The study was perfomed between May 2025 and December 2025.

All patients provided written informed consent following the principles of the 1964 Declaration of Helsinki.

The following four anthropometric parameters were measured: height, body weight, waist circumference, and hip circumference. All measurements were performed according to the Martin–Saller methodology. The following anthropometric indexes – BMI (body mass index), Waist/Hip ratio, Waist/Height ratio, ABSI (a body shape index), ABSI z-score, BRI (body roundness index) and BSA (body surface area) were calculated using corresponding formulas, as follows- $BMI=weight/height^2$, $ABSI=waist\ circumference/BMI^{2/3} x\ height^{1/2}$, $BRI= 364.2- 365.5\times\sqrt{[1-((waist\ circumfrence/2\pi)^2/(0.5\times height)^2)]}$, $BSA=0.007184\times Height^{0.725}\times Weight^{0.425}$.

In all examined patients, a standard transthoracic echocardiographic evaluation was performed. For the purposes of the study, the following echocardiographic parameters were optained: interventricular septum thickness in diastole (IVSd), left ventricular posterior wall thickness in diastole (LVPWd), and left ventricular internal diameter in end-diastole (LVIDd). In addition, left ventricular mass (LV mass), left ventricular mass index (LVMI), and relative wall thickness (RWT) were calculated by the corresponding formulas, as follows- $LVM=0.8\times[1.04((IVSd+LVIDd+PWTd)^3-(LVIDd)^3)]+ 0.6$, $LVMI=LVM/BSA$, $RWT=(2xLVPWd)/LVIDd$.

Statistics. Pearson's correlation was used to assess the correlations between the variables, and Pearson's correlation coefficient (PC) was calclated as well. The value of the coefficient was used to estimate the correlation's strength: low correlation 0.01–0.30; moderate 0.30–0.50; strong 0.50–0.70; high 0.70–0.90, and very high correlation >0.90. A level of statistical significance $p < 0.05$ was used. Data processing and statistical analyses were performed using SPSS Statistics version 23.0.

Results

The obtained results of the studied anthropometric and cardiological parameters are presented in **Tables 1 and 2**.

Table 1. Anthropometric parameters in male Bulgarian patients with arterial hypertension

Parameters	N	Mean	SE	SD
WC (cm)	60	109.74	2.19	13.85
HC (cm)	60	107.32	1.63	10.29
Weight (kg)	60	90.45	2.92	18.44
Height (cm)	60	171.42	1.11	7.03
BMI (kg/m^2)	60	30.82	0.88	5.56
WHR	60	1.02	0.01	0.08
WHtR	60	0.64	0.01	0.08
ABSI	60	0.10	0.01	0.07
ABSI-z score	60	0.38	0.18	1.13
BRI	60	6.54	0.32	2.04
BSA (m^2)	60	2.07	0.03	0.22

WC-waist circumference; HC- hip circumference; BMI- body mass index; WHR ratio- waist to hip ratio; WHtR waist to height ratio; ABSI- a body shape index; BRI- body roundness index; BSA-body surface area.

Table 2. Cardiac parameters in male Bulgarian patients with arterial hypertension

Parameters	N	Mean	SE	SD
IVSd (mm)	60	13.75	0.27	1.70
LVPWd (mm)	60	12.60	0.22	1.41
LVIDd (mm)	60	48.87	1.03	6.52
LVmass (g)	60	261.02	12.85	81.28
LVMI (g/m^2)	60	125.52	3.88	24.53
RWT	60	0.52	0.01	0.08

IVSd-intraventricular septum in diatole; LVPWd- left ventricle posterior wall in diastole; LVIDd- left ventricle internal diameter in diastole; LV mass- left ventricle mass; LVMI- left ventricle mass index; RWT- relative wall thickness

Correlations between Interventricular septum thickness in diastole (IVSd) and some anthropometric parameters.

Strong positive significant correlations were detected between IVSd on one hand and body weight (PC 0.517; $p < 0.001$), WC (PC 0.599; $p < 0.001$), BMI (PC 0.662; $p < 0.001$), Waist/Height ratio (PC 0.645; $p < 0.01$) and BRI (PC 0.662; $p < 0.001$) on the other hand. Moderate positive significant correlations were discovered between IVSd and HC (PC 0.492; $p < 0.001$), waist/ hip ratio (PC 0.398; $p < 0.001$) and BSA (PC 0.455; $p < 0.001$).

Correlations between Left ventricular posterior wall thickness in diastole (LVPWd) and some anthropometric parameters.

Strong positive significant correlations were observed between LVPWd and body weight (PC 0.582; $p < 0.001$), WC (PC 0.605; $p < 0.001$), HC (PC 0.513; $p < 0.001$) BMI (PC 0.662; $p < 0.001$), Waist/Height ratio (PC 0.619; $p < 0.001$) and BRI (PC 0.631; $p < 0.001$) and BSA (PC 0.527; $p < 0.001$). A moderate positive significant correlation was discovered between LVPWd and waist/ hip ratio (PC 0.371; $p < 0.01$).

Correlations between left ventricular internal diameter in diastole (LVIDd) and *some anthropometric parameters*

Left ventricular internal diameter in diastole (LVIDd) demonstrated high positive significant correlations with body weight (PC 0.777; p<0.001) and BSA (PC 0.811; $p<0.001$), strong positive significant correlatins with height (PC 0.507; $p<0.001$), WC (PC 0.630; p<0.001), HC (PC 0.690; p<0.001), BMI (PC 0.579; p<0.001), and moderately positive once with waist-to-height ratio (PC 0.428; p<0.01), BRI (PC 0.448; p<0.01) (Table 3).

Table 3. Correlations between some cardiac and anthropometric parameters in Bulgarian male patients with arterial hypertension.

Anthropometric parameter	IVSd		LVPWd		LVIDd	
	r (PC)	P	r (PC)	P	r (PC)	P
Height	-.176	0,278	-.105	0,519	**.507**	**0,001**
Weight	**.517**	**0,001**	**.582**	**0,001**	**.777**	**0,001**
WC	**.599**	**0,001**	**.605**	**0,001**	**.630**	**0,001**
HC	**.492**	**0,001**	**.513**	**0,001**	**.690**	**0,001**
BMI	**.662**	**0,001**	**.662**	**0,001**	**.579**	**0,001**
WHR	**.398**	**0,01**	**.371**	**0,02**	.146	0,370
WHtR	**.645**	**0,000**	**.619**	**0,001**	**.428**	**0,001**
ABSI	-.197	0,222	-.207	0,201	.068	0,676
ABSI z-score	.073	0,656	.046	0,779	.046	0,779
BRI	**.662**	**0,001**	**.631**	**0,001**	**.448**	**0,001**
BSA	**.455**	**0,003**	**.527**	**0,001**	**.811**	**0,001**

Correlations between left ventricular mass (LV mass) and some anthropometric parameters

High positive significant correlations were detected between Left ventricular mass and weight (PC 0.893; p<0.001), WC (PC 0.782; p<0.001), HC (PC 0.802; p<0.001), BMI (PC 0.794; p<0.001) and BSA (PC 0.882 p<0.001). Strong positive significant correlations were detected with waist to height ratio (PC 0.639; p<0.001) and BRI (PC 0.663; p<0.001). A moderate positive significant correlation was detected with the height (PC 0.318; p<0.05) (**Table 4**).

Correlations between left ventricular mass index (LVMI) and some anthropometric parameters

High positive significant correlations were detected between Left ventricular mass index and weight (PC 0.786; p<0.001), WC (PC 0.755; p<0.001), HC (PC 0.709; p<0.001), BMI (PC 0.770; p<0.001) and BSA (PC 0.763; p<0.001). Strong positive significant correlations were discovered with waist to height ratio (PC 0.670; p<0.05) and BRI (PC 0.689; p<0.001). A moderate positive correlation was revealed between LVMI and W/H ratio (PC 0.359; p<0.05) (**Table 4**).

Correlations between RWT (relative wall thickness) and some anthropometric parameters

The relative wall thickness showed a moderate negative significant correlation with heigh (PC -0.488; p<0.001) only (**Table 4**).

Table 4. Correlations between LV mass, LVMI, RWT cardiac parameters and some anthropometric parameters in Bulgarian male patients with arterial hypertension

Anthropometric parameter	LV mass		LVMI		RWT	
	r (PC)	P	r (PC)	P	r (PC)	P
Height	**.318**	**0,05**	.165	0,308	**-.488**	**0,001**
Weight	**.893**	**0,001**	**.786**	**0,001**	-.161	0,321
WC	**.782**	**0,001**	**.755**	**0,001**	-.017	0,919
HC	**.802**	**0,001**	**.709**	**0,001**	-.155	0,340
BMI	**.794**	**0,001**	**.770**	**0,001**	.073	0,655
WHR	.272	0,089	**.359**	**0,04**	.197	0,223
WHtR	**.639**	**0,001**	**.670**	**0,001**	.156	0,336
ABSI	-.074	0,648	-.134	0,410	-.206	0,203
ABSI z-score	.043	0,791	.078	0,633	.028	0,866
BRI	**.663**	**0,001**	**.689**	**0,001**	.148	0,362
BSA	**.882**	**0,001**	**.763**	**0,001**	-.233	0,147

Discussion

The present study demonstrates significant and clinically relevant associations between anthropometric parameters and echocardiographic markers of left ventricular structure and geometry in men with arterial hypertension. These findings highlight the important role of body size and adiposity in modulating hypertensive cardiac remodeling and support the concept that anthropometric characteristics contribute substantially to myocardial structural adaptation beyond the effects of elevated blood pressure alone.

A consistent positive relationship was observed between traditional anthropometric measures, including body weight, body mass index, waist circumference, and hip circumference, and echocardiographic indices of left ventricular wall thickness, such as interventricular septal thickness and posterior wall thickness in diastole. These findings align with previous evidence demonstrating that excess body mass is a major determinant of myocardial hypertrophy in hypertensive patients [7, 14]. The observed correlations likely reflect the combined impact of increased hemodynamic load, augmented circulating volume, and obesity-related metabolic and inflammatory pathways that promote myocardial growth and fibrosis [10].

Left ventricular internal diameter in diastole showed strong correlations with body weight and body surface area and moderate associations with indices reflecting central adiposity. This pattern suggests that increased body size in hypertensive men is associated not only with concentric wall thickening but also with chamber enlargement, indicative of eccentric remodeling. Such remodeling patterns have been linked to a higher risk of progression to heart failure and adverse cardiovascular outcomes [5, 11]. The particularly strong correlation between body surface area and left ventricular internal diameter emphasizes the importance of accounting for body size when interpreting echocardiographic dimensions [3].

Left ventricular mass and left ventricular mass index demonstrated the strongest correlations with anthropometric parameters, particularly body weight, body mass index, waist circumference, hip circumference, and body surface area. These findings are consistent with prior studies indicating that obesity is a powerful independent determinant of left ventricular mass in hypertensive individuals [4, 14]. The magnitude of these associations in the present male cohort suggests that excess body mass may substantially amplify the structural cardiac effects of arterial hypertension.

In contrast, relative wall thickness showed limited associations with anthropometric indices, with a significant inverse relationship observed only with height. These findings suggest that relative wall thickness may be less sensitive to adiposity-related influences and more reflective of intrinsic ventricular geometry and pressure-loading conditions. Previous research has indicated that relative wall thickness and left ventricular mass may vary independently, particularly in individuals with larger body size, which may explain the weaker correlations observed [5, 9].

The examined anthropological indices waist-to-height ratio and body roundness index demonstrate significant correlations with several echocardiographic parameters, whereas a body shape index and its z-score were not significantly related to left ventricular structure. These findings suggest that not all emerging anthropometric indices are equally informative in the context of hypertensive cardiac remodeling. Indices incorporating both body size and central adiposity may better reflect the hemodynamic and metabolic burden imposed on the myocardium, whereas a body shape index appears to have limited applicability in this clinical setting [1, 8, 6].

Hypertensive men are more likely to develop increased left ventricular mass and altered ventricular geometry compared with women, even at comparable blood pressure levels [13, 12]. Major hypertension-focused studies have further demonstrated that left ventricular hypertrophy is highly prevalent in men and represents a strong predictor of adverse cardiovascular outcomes [2]. The findings of the present study therefore provide clinically relevant insight into a population at particularly high risk of hypertensive heart disease.

The results suggest that simple anthropometric measures obtained during routine examination may provide valuable information regarding the likelihood of adverse left ventricular remodeling in men with arterial hypertension as a clinical perspective. Patients with increased body mass and central obesity may benefit from closer echocardiographic surveillance and more aggressive lifestyle and therapeutic interventions aimed at weight reduction and cardiovascular risk modification.

The cross-sectional design precludes causal inference, and additional longitudinal studies are required to determine whether changes in anthropometric parameters directly influence the progression or regression of left ventricular remodeling. Additionally, potential confounding factors such as duration of hypertension, type of antihypertensive therapy, and metabolic variables were not accounted for and may have influenced the observed relationships. Nevertheless, the consistency and biological plausibility of the observed associations support the validity of the findings.

Conclusion

Anthropometric parameters are closely related to echocardiographic markers of left ventricular structure and remodeling in men with arterial hypertension. Measures reflecting overall and central adiposity, including body weight, body mass index, waist and hip circumference, waist-to-height ratio, body roundness index, and body surface area, demonstrated consistent associations with left ventricular wall thickness, chamber dimensions, and myocardial mass. In contrast, a body shape index showed limited utility in characterizing hypertensive cardiac remodeling. Relative wall thickness was largely independent of adiposity-related measures, with height being the only significant determinant. These findings highlight the importance of comprehensive anthropometric assessment in the evaluation of hypertensive patients and suggest that simple, routinely obtained body measurements may facilitate identifying individuals at increased risk of adverse left ventricular remodeling.

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