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ORIGINAL ARTICLE

Blood pressure variability in controlled and uncontrolled blood pressure and its association with left ventricular hypertrophy and diastolic function

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High systolic blood pressure (SBP) variability has been associated with higher risk for target-organ damage. In a cross-sectional study done in a tertiary outpatient hypertension clinic, we compared short-term SBP variability among controlled and uncontrolled hypertensive patients and evaluated the association between higher levels of SBP variability and diastolic function and left ventricular hypertrophy (LVH). Patients were evaluated by 24-h ambulatory blood pressure monitoring and transthoracic Doppler echocardiogram. Blood pressure (BP) variability was evaluated by the time-rate index and high variability corresponded to index values in the top quartile of distribution. Echocardiographic parameters were compared in patients with and without higher BP variability within controlled and uncontrolled office BP (⩽140/90 mm Hg). The analyses included 447 patients with 58 ± 12 years of age, 67% were women, 68% white, 43% current or previous smokers and 32% with diabetes mellitus. Among the whole sample, 137 patients had controlled and 310 uncontrolled BP. The 75th percentile cutoff points for the time-rate index were 0.502 mm Hg min^{-1} and 0.576 mm Hg min^{-1} for participants with controlled and uncontrolled BP, respectively. After adjustment for confounders, the time-rate index did not differ between controlled and uncontrolled patients. BP variability was not associated with LVH or diastolic function in controlled and uncontrolled BP after adjustment for 24-h SBP and age. Patients with controlled and uncontrolled BP had similar SBP variability assessed by time-rate index, which was not associated with LVH or diastolic function. These findings should be confirmed in studies with larger sample size.

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INTRODUCTION

Short-term blood pressure (BP) variability assessed by 24-h ambulatory blood pressure monitoring (24-h ABPM) has been associated with cardiovascular prognosis and target-organ damage.[1–3] The standard deviation (s.d.) of the mean blood pressure,[1] the coefficient of variability[4] and the rate of BP variation in time defined as the time-rate index,[5,6] among other indexes,[7,8] have been used to measure the short-term BP variability. The time-rate index was positively associated with increased carotid thickness[5] and left ventricular mass[9] and with worsening of renal function in hypertensive[10] patients and in normotensive subjects with coronary arteriosclerosis.[11] An inverse association of time-rate index with ankle-brachial index (ABI), a marker of vascular damage, was described in hypertensive patients.[5] The long-term BP variability assessed by visit-to-visit systolic blood pressure (SBP) was also independently associated with mortality in a 9.9-year follow-up study of individuals not taking blood pressure-lowering drugs.[12]

Despite this body of evidence, guidelines do not yet recommend the evaluation of BP variability in the routine 24-h ABPM interpretations.[13,14] The European Guideline for 24-h ABPM includes BP variability among possible additional variables to stratify the risk of patients with hypertension, but does not recommend its use in clinical practice.[13] Therefore, additional studies are required to demonstrate if BP variability improves the risk stratification of patients with hypertension.[15]

In this study, we investigate whether short-term BP variability is influenced by BP control in patients with hypertension, and whether higher SBP variability is associated with left ventricular hypertrophy (LVH) and left ventricle diastolic function evaluated by echocardiogram.

MATERIALS AND METHODS

We conducted a cross-sectional study, enrolling patients who were consecutively referred to the tertiary outpatient hypertension clinic of the Hospital de Clinicas de Porto Alegre, to be screened to participate in the MONITOR study.[16] Patients aged 18–80 years without secondary hypertension[14] and without clinical manifestations of coronary artery disease, heart failure (New York Heart Association (NYHA) class III or IV), cerebrovascular disease or creatinine higher than 2 mg dl^{-1} in the previous 6 months were eligible. All participants provided a signed informed consent form. The project and the informed consent form were approved by the ethics committee of the Hospital de Clínicas de Porto Alegre, which is accredited by the Office of Human Research Protections as an Institutional Review Board.

Patients underwent assessment of clinical, demographic, socioeconomic (years at school) and lifestyle (current or previous smoker) characteristics. Patients with history of coronary angioplasty or revascularization, carotid endarterectomy, acute myocardial infarction, angina, heart failure, cerebral vascular accident or transient ischaemic attack were classified as having cardiovascular disease. Diabetes mellitus was determined by fasting plasma glucose ⩾ 126 mg dl^{-1}, glycosylated haemoglobin 6.5% or the use of antidiabetic medication.[17] Patients referred with antihypertensive prescription were considered to be on antihypertensive treatment. There

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were almost no treatment-naive patients or those who started treatment recently.

Standardized[18,19] office blood pressure was measured using an oscillometric validated device (OMRON HEM 705 CP, OMRON, Matsuzaka, Mie, Japan), and the average of four measurements, obtained in two visits, was used in the analysis. Patients with BP levels $\geqslant$ 140/90 mm Hg using BP-lowering agents were classified as having uncontrolled blood pressure.[18,19]

All participants underwent 24-h ABPM during a normal working day with the Spacelabs equipment, model: 90207 (Spacelabs Healthcare; Redmond, WA, USA). Readings were taken automatically at 15-min intervals during the day (7:00–23:00) and 20-min intervals during the night (23:00–07:00).[14] Patients with <6 nocturnal or <18 diurnal measurements were excluded from analysis.

The time-rate index was employed to assess the 24-h SBP variability. It is defined as the first derivative of the values of SBP by time. This index allows the calculation of the sum of angular coefficients from measurement to measurement and was calculated by the following formula:[5]

$$R = |r| = \frac{\sum_{i=1}^{N-1} |ri|}{N-1}$$

Transthoracic echocardiogram with colour Doppler and tissue Doppler imaging was done with an Philips EnvisorC, Philips, Andover, MA, USA. From the bidimensional parasternal longitudinal views, we measured left ventricular end-diastolic diameter, left ventricular end-systolic diameter, septal and posterior wall thicknesses, left atrial diameter and aortic root diameter. Ejection fraction was calculated by the use of Teicholz formula. Left ventricular mass was calculated according to American Society of Echocardiography criteria[20] and indexed to body surface area and to height[2.7].[20–22] Relative wall thickness was calculated as 2 × posterior wall thickness divided by left ventricular end-diastolic diameter. Left ventricular hypertrophy (LVH) was defined as >95 g m^{-2} for women, and >115 g m^{-2} for men, and increased relative wall thickness as >0.42.[20]

Diastolic function was assessed by mitral inflow and tissue Doppler imaging obtained in the apical four-chamber view. Analysis of the mitral inflow included rapid ventricular filling wave peak velocity (*E*) and deceleration time, atrial contraction wave peak velocity (*A*) and *E/A* ratio. Early diastolic myocardial velocity (*e′*), diastolic myocardial velocity after atrial contraction (*A′*) and *E′/A′* ratio were obtained from the lateral mitral annulus.[23,24] Diastolic function was considered abnormal when lateral *e′*-wave <10 and normal when $\geqslant 10$.[23,24] The systolic function measurements were evaluated by calculating of the ejection fraction by using the Teicholz formula from the linear measurements of the left ventricle cavity on the parasternal longitudinal plane at the mitral valve chordae.[20]

LVH was also assessed by electrocardiogram by obtaining two measures of each electrocardiographic variable, taking into account the average for the calculation of the LVH indexes. The electrocardiographic tracing was assessed by the same cardiologist to assess LVH using the Cornell voltage criteria.[25,26]

Statistical analysis

The time-rate index among patients with controlled and uncontrolled BP was compared and the result was adjusted for age, 24-h SBP, body mass index and serum glucose levels.

Time-rate SBP variability values were divided into quartiles and the top quartile was taken as high variability in the analyses in patients with controlled and uncontrolled BP. The respective values were $\geqslant 0.502$ mm Hg min^{-1} and 0.576 mm Hg min^{-1}. The association between high variability and echocardiographic parameters was explored separately in patients with controlled BP and uncontrolled BP (systolic $\geqslant 140$ mm Hg or diastolic $\geqslant 90$ mm Hg).

There was not *a priori* sample size calculation, but considering a *P* alpha of 5%, power of 80% and that in the group with controlled BP the septal thickness would have an average of 9 ± 2 mm, we estimated a sample of 90 patients to detect a difference of 15% in the septal thickness (ratio of 1:1 of patients with lower and higher time rate). Categorical and continuous variables were compared with Pearson's χ^2-test and the Student's *t*-test, respectively. All results were presented as mean and s.d. for the continuous variables and as absolute numbers and percentages for the categorical variables with the respective confidence intervals of 95%. Two-sided values of $P < 0.05$ were considered significant.

To compare the time-rate index between patients with controlled and uncontrolled BP and to evaluate the possible independent association between echocardiographic variables and time-rate index, analysis of covariance was used. Multiple linear regression models with adjustment for age and 24-h SBP were used to evaluate the association between the time rate and parameters of LVH and diastolic function. We also analyzed this association considering three different groups of diastolic dysfunction: normal ($e' \geqslant 10$ cm s^{-1}), abnormal grade I ($e' < 10$ cm s^{-1} and $E/e' \leqslant 8$), and abnormal grade II–III ($e' < 10$ cm s^{-1} and $E/e' > 8$).[23,24]

All data were analyzed using the Statistical Package for Social Science program (SPSS version 17; SPSS Inc., Chicago, IL, USA).

Table 1. Characteristics of the sample

	Total = 447	*Lower BPV* (n = *102*)	*Higher BPV* (n = *35*)	P-*value*	*Lower BPV* (n = *232*)	*Higher BPV* (n = *78*)	P-*value*
		Controlled BP			*Uncontrolled BP*		
Age (years)	58 ± 12.0	53.4 ± 11.5	56.6 ± 11.5	0.16	58.9 ± 11.8	61.0 ± 11.2	0.16
Women	300 (67.1%)	73 (71.5%)	27 (77.1%)	0.52	147 (63.4%)	53 (67.9%)	0.46
Whites	305 (68.2%)	70 (68.6%)	26 (74.3%)	0.53	163 (70.3%)	46 (59.0%)	0.07
BMI (kg m^{-2})	30.5 ± 5.5	31.1 ± 6.2	31.7 ± 5.4	0.61	30.1 ± 5.3	30.0 ± 5.4	0.90
Smoker	193 (43.2%)	46 (45.1%)	20 (57.1%)	0.20	97 (41.8%)	30 (38.5%)	0.43
Diabetes mellitus	143 (32.0%)	23 (22.5%)	7 (20%)	0.73	82 (35.3%)	31 (39.7%)	0.52
Cardiovascular disease	110 (24.6%)	22 (21.6%)	8 (22.8%)	0.87	54 (23.3%)	26 (33.3%)	0.08
Score Framingham				0.38			0.37
Low	171 (38.3%)	63 (61.8%)	20 (57.1%)		68 (29.3%)	20 (25.6%)	
Creatinine (mg dl^{-1})	0.94 ± 0.3	0.92 ± 0.3	0.86 ± 0.2	0.35	0.94 ± 0.2	1.01 ± 0.4	0.08
No antihypertensive	2.3 ± 1.2	2.0 ± 1.0	1.9 ± 1.0	0.75	2.4 ± 1.2	2.3 ± 1.2	0.55
Years of study	3.9 ± 2.7	3.7 ± 2.9	4.1 ± 2.6	0.43	4.1 ± 2.8	3.4 ± 2.5	0.36
Total cholesterol (mg dl^{-1})	203.2 ± 45.4	203.7 ± 48.2	201.3 ± 41.7	0.80	199.9 ± 41.4	213.1 ± 53.5	0.03
HDL cholesterol (mg dl^{-1})	51.6 ± 17.8	50.9 ± 15.5	51.4 ± 16.3	0.87	50.9 ± 15.5	54.4 ± 27.1	0.18
LDL cholesterol (mg dl^{-1})	120.6 ± 37.6	122.4 ± 39.5	119.7 ± 33.8	0.73	118.5 ± 35.8	124.8 ± 41.8	0.22
Triglycerides (mg dl^{-1})	158.1 ± 95.9	153.0 ± 94.1	135.7 ± 55.5	0.34	159.5 ± 107.7	170.3 ± 107.7	0.45
24-h SBP (mm Hg)	137.0 ± 17.6	123.9 ± 9.8	126.8 ± 10.2	0.14	139.4 ± 15.2	151.4 ± 20.6	<0.001
24-h DBP (mm Hg)	80.8 ± 12.6	75.1 ± 8.0	75.4 ± 7.6	0.85	81.8 ± 12.1	87.9 ± 16.3	0.001
Office SBP (mm Hg)	150.9 ± 21.5	128.5 ± 7.8	127.8 ± 7.4	0.63	158.1 ± 15.5	169.9 ± 21.2	<0.001
Office DBP (mm Hg)	86.2 ± 12.3	78.6 ± 6.5	78.4 ± 6.3	0.87	88.3 ± 11.9	93.3 ± 14.1	0.003
LVH Cornell	14.9 ± 6.9	12.6 ± 5.9	12.9 ± 5.0	0.75	15.3 ± 6.9	17.7 ± 7.9	0.02
LVH LIFE	1844.8 ± 882.5	1636.6 ± 792.7	1710.4 ± 764.4	0.64	1870.2 ± 897.3	2100.9 ± 944.4	0.07

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; LVH, left ventricular hypertrophy; SBP, systolic blood pressure.

RESULTS

Of the 560 patients assessed, 447 (80%) were included in the analysis (20 patients were excluded due to missing echocardiographic data and 93 due to missing time-rate index). Patients not included in analyses because of missing data were similar to the patients included in regard to age (57 ± 11 years), gender (57% women) and mean 24-h SBP (139 ± 17 mm Hg). The characteristics of the studied sample are described in Table 1. There was a predominance of overweight white women with an average age of 58 ± 12 years and frequent history of smoking and diabetes mellitus (43% and 32%, respectively). Most patients were already on antihypertensive treatment (95%).

Patients with uncontrolled BP had higher 24-h SBP variability (0.502 ± 0.12 mm Hg min^{-1} versus 0.436 ± 0.10 mm Hg min^{-1}; $P < 0.001$). The difference lost significance after adjustment for age, 24-h SBP, BMI and serum glucose (0.479 mm Hg min^{-1} versus 0.460 mm Hg min^{-1}; $P = 0.49$). Those with controlled and uncontrolled BP and high BP variability were older, had higher mean values of pulse pressure, SBP and diastolic blood pressure on 24-h ABPM, and had a higher frequency of previous history of cardiovascular disease in comparison with participants without high BP variability.

Table 2 shows that among patients with uncontrolled BP there was a significantly higher LVH, septal thickness, relative wall thickness and left ventricular mass corrected by height$^{2.7}$ or by body surface area in patients with high BP variability. Indices of diastolic function were not different in patients with and without higher BP variability either in patients with controlled or in uncontrolled blood pressure (Table 3). Table 4 shows that in the uncontrolled BP patients, after adjustment for age and 24-h SBP, the associations between higher BP variability and echocardiographic parameters were no longer significant. Only relative wall thickness remained marginally significant.

Among the whole sample, 38% of the patients ($n = 172$) were classified as grade II or III of diastolic dysfunction. Considering only these patients with higher risk profile, we also did not find an independent association between the time-rate index and echocardiographic variables of diastolic function (data not shown).

Considering patients with controlled and uncontrolled BP, a multiple regression analysis did not show an independent correlation between the time-rate index and variables of LVH and diastolic function (Table 5).

DISCUSSION

In this study of patients with hypertension referred to a specialized clinic SBP variability measured by the time-rate index was not different in patients with controlled and uncontrolled BP after adjustment for confounders. BP variability was not associated with the indices of LVH in patients with uncontrolled BP after adjustment for 24-h SBP and age. We used the time-rate index as a measure of the short-term SBP variability because it is an index that measures how fast or how slow and in which direction SBP values change.[5] Theoretically, an index with such characteristic could measure more precisely the mechanical stress on the cardiovascular system. Other short-term measurements of BP variability, such as the s.d. or the coefficient of BP variation, seem to be less precise to assess the magnitude of BP variability.[5]

Despite being an intermittent method of blood pressure measurement, 24-h ABPM has the potential to provide more accurate information about BP variation throughout the day than the traditional measurement in the medical office.[4] Moreover, there is growing evidence showing that the increase in short-term variability of SBP obtained by the time-rate index, beyond other parameters, is useful as a predictor of target-organ damage and cardiovascular events.[5,6,9–11,27]

Zakopoulos *et al*.[5] in a cross-sectional study with 539 individuals, demonstrated an independent association between the time-rate index and carotid thickness measured by ultrasound. Our group described the association between this index and the ABI in a cross-sectional study with 425 patients. Among the whole sample, 58 patients (13.6%) had altered ABI. For the normal and abnormal ABI groups, the time-rate index was 0.469 ± 0.119 and 0.516 ± 0.146 mm Hg min^{-1} ($P = 0.007$), respectively. Time-rate index was associated with ABI, regardless of age, and the variability of 24-h SBP estimated by the time-rate index was associated inversely with ABI. These results enhanced the hypothesis that higher variability of blood pressure can be an independent variable related to target-organ damage beyond the absolute values of blood pressure.[6]

In a cohort of normotensive patients, with the suspicion of coronary artery disease, Manios *et al*.[11] assessed the association between the rate of variation of blood pressure defined through the same index and the severity and topography of coronary lesions. Patients with coronary artery disease showed a rate of variation of SBP significantly higher during the day compared to controls. More marked variations of BP can produce greater tension in the arterial wall and have an additive role of vascular risk factors in the severity of coronary lesions even in normotensive patients.[11]

Aiming to identify pathophysiological differences between stroke subtypes, a Greek cohort study, with 24-h ABPM performed within the first 24 h after the event index, showed that the time-rate index was higher among patients with arteriosclerosis of the large arteries (0.692 mm Hg min^{-1}; confidence interval (CI) 95%: 0.627–0.757) in comparison with patients with lacunar complications (0.609 mm Hg min^{-1}; IC 95%: 0.579–0.640) or unknown aetiology (0.586 mm Hg min^{-1}; IC 95%: 0.522–0.649). Furthermore, an increase of 0.1 mm Hg min^{-1} in the systolic blood pressure variation rate in 24 h was associated with a 1.96 increase in the risk of unfavourable outcome (IC of 95%: 1.16–3.32).[27]

Although the results of different studies show that BP variability can provide additional prognostic information for primary

Table 2. Echocardiographic measurements of left ventricular hypertrophy

	Total = 447	*Lower BPV* (n = *102*)	*Higher BPV* (n = *35*)	P-*value*	*Lower BPV* (n = *232*)	*Higher BPV* (n = *78*)	P-*value*
		Controlled BP			*Uncontrolled BP*		
Left atrium (mm)	41.5 ± 5.3	40.8 ± 5.6	40.7 ± 4.5	0.96	41.6 ± 5.1	42.4 ± 5.7	0.27
Septum (mm)	11.5 ± 2.0	10.8 ± 1.7	10.9 ± 1.1	0.59	11.7 ± 2.0	12.4 ± 2.4	0.007
Ejection fraction (Teichholz-%)	67.7 ± 8.5	68.7 ± 9.3	69.4 ± 5.4	0.68	66.9 ± 8.4	67.7 ± 8.9	0.51
LV mass/height$^{2.7}$ (g m$^{-2.7}$)	53.7 ± 17.5	47.4 ± 15.6	50.2 ± 11.9	0.33	54.6 ± 16.6	60.7 ± 21.4	0.01
LV mass/height (g m^{-1})	121.3 ± 40.6	108.0 ± 37.8	112.7 ± 27.5	0.51	123.7 ± 38.6	134.9 ± 48.7	0.04
LV mass/BSA (g m^{-2})	106.7 ± 34.2	93.9 ± 31.9	97.6 ± 22.4	0.53	109.1 ± 32.3	119.8 ± 40.7	0.02
RWT (cm)	0.44 ± 0.1	0.42 ± 0.1	0.42 ± 0.1	0.88	0.44 ± 0.1	0.49 ± 0.1	0.004

Abbreviations: BPV, blood pressure variability; BSA, body surface area; LV, left ventricle; RWT, relative wall thickness.

Table 3. Echocardiographic measurements of diastolic function

	Total = 447	*Lower BPV* (n = *102*)	*Higher BPV* (n = *35*)	P-*value*	*Lower BPV* (n = *232*)	*Higher BPV* (n = *78*)	P-*value*
		Controlled BP			*Uncontrolled BP*		
Diastolic dysfunction	172 (38.5%)	28 (27.4%)	10 (28.6%)	0.82	100 (43.1%)	34 (43.6%)	0.78
E-wave ($m\,s^{-1}$)	0.77 ± 0.2	0.79 ± 0.2	0.81 ± 0.2	0.72	0.77 ± 0.2	0.75 ± 0.2	0.57
A-wave ($m\,s^{-1}$)	0.89 ± 0.4	0.87 ± 0.5	0.82 ± 0.1	0.53	0.92 ± 0.4	0.91 ± 0.2	0.94
E/A Ratio (m)	0.96 ± 0.5	1.0 ± 0.3	1.0 ± 0.4	0.58	0.94 ± 0.5	0.93 ± 0.8	0.96
e′-wave ($cm\,s^{-1}$)	12.2 ± 9.4	12.0 ± 3.3	12.1 ± 3.4	0.85	12.2 ± 10.5	12.4 ± 12.7	0.87
A′-wave ($cm\,s^{-1}$)	14.9 ± 8.1	14.5 ± 9.4	14.5 ± 4.3	0.98	15.0 ± 8.8	15.3 ± 5.2	0.78
E/e′ ratio	7.4 ± 4.2	7.0 ± 2.3	6.8 ± 1.8	0.95	7.6 ± 5.3	7.5 ± 2.5	0.77

Table 4. Analysis of covariance—variables associated with LVH in patients with uncontrolled BP (adjusted for age and 24-h SBP)

	Group	*Observed*	*Adjusted*	P-*value*
Septum (mm)	Lower BPV	11.7	11.9	0.31
	Higher BPV	12.4	12.2	
LV mass/height$^{2.7}$ ($g\,m^{-2.7}$)	Lower BPV	54.6	56.3	0.27
	Higher BPV	60.6	58.9	
LV mass/BSA ($g\,m^{-2}$)	Lower BPV	109.1	113.0	0.53
	Higher BPV	119.8	115.9	
RWT (cm)	Lower BPV	0.44	0.45	0.03
	Higher BPV	0.49	0.48	

Abbreviations: BSA, body surface area; LV, left ventricle; RWT, relative wall thickness.

Table 5. Association between the time-rate index and variables of LVH and diastolic function in multiple linear regression model

Variables	*Beta*	*95% CI*	P-*value*
Controlled BP (n = *137*)			
Septum	0.015	−0.229 to 0.271	0.86
RWT	−0.02	−0.211 to 0.154	0.75
E/e′	−0.06	−4.679 to 2.305	0.50
Uncontrolled BP (n = *310*)			
Septum	0.05	−0.109 to 0.274	0.27
RWT	0.11	−0.008 to 0.211	0.07
E/e′	−0.04	−6.28 to 2.81	0.45

Abbreviations: BP, blood pressure; CI, confidence interval; RWT, relative wall thickness. The result was adjusted for age and 24-h SBP.

prevention, as it can detect significant cardiovascular risk, the current guidelines for hypertension and 24-h ABPM do not recommend to determine BP variability in the evaluation of hypertensive patients.[18,19] The results of the present study do not confirm the previous results showing an independent association between higher levels of short-term variability and target-organ damage. The patients' characteristics, such as their high cardiovascular risk and the use of antihypertensive treatment may explain our negative results. The absence of association between BP variability and echocardiographic parameters is in line with the findings of a large data-based cohort study of 11 populations involving 9000 participants (41% were hypertensive subjects), with hard cardiovascular end points. After a mean follow-up period of 11.3 years the short-term variability measured by the average real variability[7] (an index also calculated with 24-h ABPM data) did not contribute significantly to risk stratification. The authors concluded that the blood pressure level was the main blood pressure-related risk factor in clinical practice.

Our study has some limitations that deserve mention. First, the cross-sectional design precludes the relationship of the causality between increased variability of BP and echocardiographic parameters. Second, we assessed the relationship between BP variability and surrogate outcomes. The latest European Guideline for management of hypertension emphasizes the identification of subclinical target-organ damage in the initial evaluation of hypertensive patients. The evaluation of LVH and diastolic function, which were the main outcome variables of the present study, can also be considered in this context as it has been shown to be a strong prognostic indicator in patients with symptomatic or asymptomatic cardiac insufficiency and is associated with higher mortality risk.[19,28] Third, a beta error cannot be excluded in some non-significant associations, in face of the small subgroups size. Finally, as we do not have the exact threshold value for the time-rate index, we used the cutoff point of 75th percentile for patients with controlled and uncontrolled BP. Our cutoff point of the time-rate index was considerably smaller than previously described in other studies with hypertensive patients.[5,9] The external validity of our findings should be confirmed in further studies, because our study was conducted in a single-centre study from a tertiary outpatient clinic and the sample had mostly middle-aged, overweight women under antihypertensive drug treatment.

In conclusion, patients with controlled and uncontrolled BP had similar BP variability assessed by the time-rate index after adjustment for confounding factors. The presence of high BP variability was associated with the indices of LVH, but this association was not significantly independent of BP and age. Our results agree with current guidelines that do not recommend variability indices in the daily interpretation of 24-h ABPM. These findings should be confirmed by studies with larger sample sized studies.

What is known about this topic?

- Short-term BP variability assessed by 24-h ABPM may be associated to target-organ damage and might be higher in uncontrolled hypertensive patients.
- The time-rate index measures how fast or how slow and in which direction SBP values change.
- Current guidelines do not recommend the use of BP variability parameters for routine use in clinical practice.

What this study adds?

- After adjustment for confounders, the time-rate index was not different in treated hypertensive patients with controlled and uncontrolled BP.
- After adjustment for confounders, BP variability was not associated with echocardiographic parameters of LVH or diastolic function.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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