ORIGINAL ARTICLE

Unattended automatic blood pressure measurements vs conventional office readings in predicting hypertension-mediated organ damage

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KEY WORDS

arterial hypertension, blood pressure measurement, hypertension-mediated organ damage, unattended automated office blood pressure, white-coat effect

ABSTRACT

INTRODUCTION Hypertension is a leading cardiovascular risk factor. Accurate blood pressure (BP) measurement is pivotal in hypertension diagnosis and management. Conventional office blood pressure measurements (OBPMs) are error-prone, exacerbated by the white-coat effect. Unattended automated office blood pressure measurement (UAOBPM) is emerging as an alternative, mitigating the white-coat effect. However, its ability to predict hypertension-mediated organ damage (HMOD) remains disputable.

OBJECTIVES This study compares UAOBPM with OBPM in terms of their association with various types of HMOD, including left ventricular hypertrophy, left atrial enlargement, left ventricular systolic and diastolic dysfunction, intima-media complex thickening, microalbuminuria, and abnormal pulse wave velocity.

PATIENTS AND METHODS A total of 219 hypertensive patients were recruited, interviewed, and examined. Subsequently, BP measurements were conducted in a randomized manner: 1) UAOBPM, after 5 minutes of solitary rest in an examination room, BP was automatically measured 3 times at 1-minute intervals; 2) OBPM, after 5 minutes of rest, a physician performed 3 consecutive BP measurements at 1-minute intervals. Subsequent evaluations aimed to detect HMOD and included echocardiography, carotid artery ultrasound, pulse wave velocity assessment, and laboratory tests.

RESULTS UAOBP values were lower than the OBP ones (mean [SD], 124.7 [14.4] vs 128.2 [14.2] mm Hg; $P < 0.001$ for systolic BP, and 73.3 [10.2] vs 75.2 [10.6] mm Hg; $P < 0.001$ for diastolic BP). Correlation and receiver operating characteristic curve analyses revealed no superiority of either method in predicting HMOD.

CONCLUSIONS The UAOBPM did not prove superior to OBPM in predicting HMOD. Further research is warranted to determine the role of UAOBPM in clinical practice.

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INTRODUCTION Hypertension, as the most important risk factor for cardiovascular diseases (CVDs), significantly contributes to the incidence of serious complications, including coronary heart disease, heart failure, and strokes.[1] Accurate measurement of blood pressure (BP) plays a crucial role in the diagnosis and management of hypertension. However, conventional office BP measurements (OBPMs) are prone to both random and systematic errors. In particular, BP increase induced by the stress related to a medical visit, known as the white-coat effect, importantly affects their accuracy.[2-5] To address these challenges, current guidelines recommend out-of-office

WHAT'S NEW?

Accurate blood pressure (BP) measurement is a crucial aspect of hypertension therapy. There is a growing concern about potential errors in conventional office measurements. One of the methods aimed at minimizing these errors is unattended BP measurement, where patients are left alone at a doctor's office during the measurement. Research suggests that BP values obtained through this method tend to be lower than those of traditional measurements. However, it remains unclear whether this method offers superior predictive value. To address this, both approaches were compared in terms of their ability to predict subclinical hypertension-mediated organ damage (HMOD). The study results suggest that although BP readings during unattended measurements were significantly lower, this method did not prove to be superior in predicting any of the various types of HMOD.

BP measurements, such as home BP monitoring (HBPM) and ambulatory BP monitoring (ABPM).[6]

Another emerging technique is an unattended, automated measurement of arterial BP.[7] This method involves a patient being left alone in a clinical setting, connected to a BP monitoring device, with automated measurements taken after a specified period. Many studies demonstrated its potential to mitigate the white-coat effect.[8-10]

However, research results are conflicting regarding the ability of the automated measurement method to better predict the presence of hypertension-mediated organ damage (HMOD),[11-13] which indicates an advanced stage of the disease. This study aims to compare the unattended BP measurement method with conventional office measurements in terms of their predictive capacity of various manifestations of HMOD, including left ventricular hypertrophy (LVH), left atrial enlargement (LAE), features of systolic and diastolic dysfunction on echocardiographic examination, intima-media complex thickening, presence of microalbuminuria, decline in glomerular filtration rate (GFR), and carotid-femoral pulse wave velocity (PWV). Additionally, these 2 methods were compared with out-of-office BP measurement (HBPM and ABPM) for their capacity of HMOD prediction.

PATIENTS AND METHODS A total of 219 individuals diagnosed with primary arterial hypertension were recruited from a hypertension outpatient clinic at a reference center. Eligible participants were individuals aged 18 years or older, free of any clinically evident CVD. Each participant underwent a comprehensive subjective examination using a standardized questionnaire, including details concerning hypertension progression, therapeutic interventions, and other risk factors. Moreover, a thorough physical examination and precise anthropometric measurements were carried out as part of the protocol.

Subsequently, arterial BP measurements were conducted. The participants were advised to abstain from alcohol consumption and cigarette smoking for a minimum of 3 hours prior to their scheduled visit. The BP assessments took place in the afternoon, in a quiet examination room at an outpatient clinic. All measurements were systematically performed adhering to the established guidelines of the European Society of Hypertension (ESH),[6] using the OMRON HEM 907 device (OMRON Corporation, Kyoto, Japan). The measurements were conducted according to 2 standardized protocols. For unattended automatic office blood pressure measurement (UAOBPM), the attending physician meticulously checked the equipment setup, provided the patient with comprehensive instructions regarding the measurement procedure, initiated the device, and left the examination room. Following a 5-minute seated rest, 3 consecutive BP measurements were automatically obtained at 1-minute intervals. For office blood pressure measurement (OBPM), the patient was provided with a 5-minute seated rest, and then the physician personally performed 3 conventional BP measurements at 1-minute intervals, refraining from engaging in any conversation with the patient.

The sequence in which the methods were employed for each participant was randomized to ensure unbiased data collection. Following the BP measurements, transthoracic echocardiography and carotid artery ultrasound were performed.

Echocardiographic examination was performed using the Vivid E95 device (GE Ultrasound, Horten, Norway), operated by a skilled practitioner. All recordings encompassed a minimum duration of 3 consecutive cardiac cycles, and were digitally archived for subsequent offline analysis. The analysis of echocardiographic images was executed offline using an EchoPack v204 workstation integrated with the ViewPoint system (GE Ultrasound). Determination of left ventricular and left atrial diameters adhered to the established guidelines set forth by the American Society of Echocardiography and the European Association for Cardiovascular Imaging.[14] Left ventricular mass (LVM) was calculated using the following formula:

$LVM = 0.8 \times 1.04 \times ([IVS + LVID + PWT]^3 - LVID^3) + 0.6\ g$[15]

where IVS represents the interventricular septum, LVID denotes the left ventricular internal diameter, and PWT signifies the posterior wall thickness. Both the LVM and left atrial size were standardized by indexing them to the body surface area. In accordance with the European Society of Hypertension (ESH) guidelines,[6] LVH was defined as values exceeding 115 g/m² in men and 95 g/m² in women. The relative wall thickness (RWT) was derived using the following equation: $2 \times PWT / LVID$. RWT was considered enlarged, if its value was equal to or above 0.43.[6] The left atrium was classified as dilated, if its indexed volume exceeded 34 ml/m².[14]

Systolic dysfunction has been defined as a global longitudinal strain (GLS) value above –20%, according to the ESH guidelines.[6]

The presence of diastolic dysfunction on echocardiographic examination was assessed according to current standards, using an algorithm designed for individuals with preserved ejection fraction.[16]

Carotid artery ultrasound imaging was performed with a high-resolution ultrasound scanner featuring a high-frequency (11 MHz) linear array transducer (GE Vivid E95). High-quality B-mode ultrasound images of the left and right common carotid arteries were captured. The automated measurement of intima-media thickness (IMT) was conducted by tracing a 1-cm segment (beginning approximately 1 cm proximal to the bifurcation point) along the outer edges of the intima and adventitia layers. Subsequently, multiple automatic measurements were taken between pairs of pixels located on both traced lines. The average IMT was computed by taking the mean of the left and right measurements. In accordance with the guidelines outlined by the ESH, an IMT value exceeding 0.9 mm was considered indicative of pathologic thickening, while the presence of atherosclerotic plaque was defined by IMT above 1.5 mm.[6]

We assessed carotid-femoral PWV using a SphygmoCor device (AtCor Medical Pty Ltd, West Ryde, New South Wales, Australia) with integrated XCEL version 1.3 software. The measurements were performed in agreement with the expert consensus document on the measurement of aortic stiffness in daily practice using PWV.[17] As per the guidelines set forth by the ESH, a PWV value exceeding 10 m/s was classified as elevated.[6]

On the next day, following an overnight fast, each participant underwent comprehensive laboratory examinations, including lipid profile, and the level of glucose, creatinine, and urea. Estimated GFR (eGFR) was calculated using the chronic kidney disease epidemiology collaboration equation.[18] Additionally, a urine sample was collected to evaluate the albumin-creatinine ratio (ACR). In accordance with the ESH guidelines, an ACR value between 30 and 300 mg/g was considered indicative of elevated albumin excretion, while eGFR below 60 ml/min/1.73 m^2 was regarded as reduced kidney function.[6]

On the same day, 24-hour ABPM was performed using the SpaceLabs 90207 device (Spacelabs Healthcare Inc., Snoqualmie, Washington, United States). The ABPM data were captured at 15-minute intervals throughout daytime (6 AM to 10 PM), and at 20-minute intervals at night (10 PM to 6 AM).

The participants were provided with instructions to conduct HBPM. They were advised to measure their BP while in a seated position, following a 5-minute rest, with 1 minute between each reading. They were specifically instructed to take 2 measurements in the morning right after waking up and 2 measurements before going to bed, consistently for a period of 7 days.

The study protocol was aligned with the ethical guidelines set forth in the 1975 Declaration of Helsinki, and received ethical approval from the Bioethics Committee of Jagiellonian University in Kraków (1072.6120.39.2020). The patients granted their written informed consent for participation in the study.

Statistical analysis Normality of the variables was assessed with the Shapiro–Wilk test. The data were analyzed using descriptive statistics, with continuous variables presented as mean (SD) and categorical variables as percentages. Variables not following normal distribution were presented as median and interquartile range. Differences between UAOBPM and attended OBPM were assessed using paired simple *t* tests. Examination of relationships between normally distributed variables involved calculating the Pearson correlation coefficients to assess a linear association between the variables. For variables that did not follow a normal distribution, the Spearman correlation was applied. The Steiger Z statistic was employed to compare the correlation coefficients between both measurement methods. Receiver operating characteristic (ROC) curves were constructed to evaluate the predictive capabilities of the considered parameters (both attended and unattended BP values) for detecting HMOD. The area under the curve (AUC) was calculated as a measure of predictive power. The comparison of ROC curves was conducted utilizing the methodology proposed by DeLong et al.[19] We calculated the statistical power to demonstrate differences in BP values between the measurement methods. Drawing upon findings from previous studies comparing these 2 methods, we anticipated an approximate 5 mm Hg difference in systolic BP (SBP) and SD of 12 mm Hg. Achieving a study power of 80% and a significance level of 5% required a sample size of 184 participants. All statistical tests were 2-tailed, and a *P* value below 0.05 was deemed significant. IBM SPSS software (version 28; SPSS Inc., Chicago, Illinois, United States) was used for all statistical analyses.

RESULTS The study population characteristics are summarized in TABLE 1. Mean (SD) age of the patients was 55.3 (13.5) years. Women constituted 55% of the participants. TABLE 1 provides distribution of individuals with specific risk factors, antihypertensive medication usage, and the proportion of participants presenting with specific types of HMOD.

Differences were observed in the BP values between UAOBPMs and OBPMs, with lower values found in the unattended measurements (mean [SD], 124.7 [14.4] vs 128.2 [14.2] mm Hg; $P < 0.001$ for SBP, and 73.3 [10.2] vs 75.2 [10.6] mm Hg; $P < 0.001$ for diastolic BP [DBP]).

The correlation coefficients between BP values obtained from both methods were high, indicating a strong positive correlation for both SBP (r = 0.835; $P < 0.001$) and DBP (r = 0.94; $P < 0.001$).

TABLE 1 Characteristics of the study population (n = 219)

Parameter		Participants
Age, y, median (IQR)		57 (48–66)
Women/men		120/99 (55/45)
Height, cm, mean (SD)		168 (10)
Weight, kg, mean (SD)		83 (15)
BMI, kg/m^2, mean (SD)		29 (4.7)
BSA, m^2, mean (SD)		1.93 (0.21)
Dyslipidemia		119 (54.3)
Diabetes mellitus		17 (7.8)
Smoking, no/yes/former		119/31/69 (54/14/32)
Antihypertensive treatment		201 (91.8)
Number of antihypertensive drugs	0	18 (8.2)
	1	48 (22.4)
	2	65 (29.7)
	3	54 (24.7)
	4	22 (10)
	5	10 (4.6)
	6	1 (0.5)
ACEI or ARB		171 (78)
Diuretics		93 (42)
Calcium channel blockers		85 (35)
β-Blockers		110 (50)
Potassium-sparing diuretics		14 (6.4)
Other antihypertensive drugs		3 (1.4)
Statins		92 (42)
LVH		17 (7.8)
RWT ≥ 0.43		55 (25)
GLS >–20%		106 (48)
LAE		45 (21)
e′ septal <7 cm/s		22 (10)
e′ lateral <10 cm/s		76 (34)
E/e′ >14		3 (1.4)
Diastolic dysfunction		11 (5)
PWV ≥10 m/s		15 (6.8)
IMT ≥0.9 mm		26 (12)
Plaque in carotid arteries		93 (42.5)
ACR 30–300 mg/g		9 (4)
eGFR <60 ml/min/1.73 m^2		2 (0.9)

Data are presented as number and percentage unless indicated otherwise.

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ACR, albumin-creatinine ratio; ARB, angiotensin receptor blocker; BMI, body mass index; BSA, body surface area; E, early mitral inflow velocity; e′, early diastolic mitral annulus velocity; eGFR, estimated glomerular filtration rate; GLS, global longitudinal strain; IMT, intima-media thickness; IQR, interquartile range; LAE, left atrial enlargement; LVH, left ventricular hypertrophy; PWV, pulse wave velocity; RWT, relative wall thickness

TABLE 2 shows mean BP values for all analyzed methods: attended and unattended measurements, HBPM, and ABPM.

Subsequently, a comprehensive analysis was conducted to assess the predictive capacity of HMOD presence using both methods, employing correlation analysis and ROC curves.

Hypertension-mediated cardiac damage For each of the measurement methods employed, a weak correlation was observed between SBP and LVM (unattended, r = 0.216; P <0.001; attended, r = 0.173; P = 0.01), as well as between DBP and LVM (unattended, r = 0.2; P = 0.003; attended, r = 0.155; P = 0.02).

To evaluate the disparities in these correlations, the Steiger Z test was employed. The outcomes indicated no distinctions in the correlation coefficients for SBP (P = 0.26) and DBP (P = 0.24).

Furthermore, a correlation with RWT was observed only for DBP, both for unattended measurements (r = 0.15; P = 0.03) and attended measurements (r = 0.135; P = 0.047). Importantly, there were no significant differences between these correlations. The findings are presented in TABLE 3.

ROC curve analysis revealed no significant differences between the 2 BP measurement methods in predicting the occurrence of LVH for either SBP or DBP (FIGURE 1).

Similarly, given the increased RWT, none of the models showed demonstrable effectiveness, regardless of the measurement methodology (FIGURE 1).

A weak correlation was found between both methods of measuring SBP and left atrial volume (unattended, r = 0.142; P = 0.04; attended, r = 0.136; P = 0.045). There were no differences between these correlations (P = 0.88). However, no significant correlation was found between DBP and left atrial size for either measurement method (TABLE 3).

ROC curve analysis revealed that both measurement methods demonstrated comparable effectiveness (FIGURE 1). However, neither method exhibited satisfactory predictive power for LAE when considering DBP (FIGURE 1).

No significant correlation was found between GLS and either SBP or DBP values, regardless of the measurement method employed (TABLE 3).

Through ROC curve analysis, effectiveness in predicting left ventricular systolic dysfunction was not substantiated for either of the methods, encompassing both SBP and DBP measurements (FIGURE 2). Comparable outcomes were observed in relation to the prediction of diastolic dysfunction (FIGURE 2).

Carotid structure A weak correlation was observed between SBP measured by both methods and the average IMT (UAOBPM, R = 0.179; P = 0.009; OBPM, R = 0.177; P = 0.01). There were no differences between the correlations (P = 0.96). No significant correlations were found for DBP (TABLE 3).

For SBP, the ROC curve model demonstrated effectiveness in predicting the presence of increased IMT, and both measurement methods exhibited similar performance (FIGURE 3). However, the model was not effective for DBP (FIGURE 3). Furthermore, the model showed no effectiveness in predicting the presence of atherosclerotic plaque in any of the cases examined (FIGURE 3).

TABLE 2 Mean (SD) values of blood pressure for various methods of measurement

Parameter	OBPM	UAOBPM	HBPM	ABPM 24 h	ABPM day	ABPM night
SBP, mm Hg	128.2 (14.2)	124.7 (14.4)[a]	128.9 (11.7)	122.1 (11.9)[a]	127.1 (12.7)	112.2 (13.2)[a]
DBP, mm Hg	75.2 (10.6)	73.3 (10.2)[a]	79.9 (8.7)[a]	74.1 (7.8)[b]	78.1 (8.5)[a]	66.1 (7.7)[a]

a *P* value <0.001 for *t* test vs OBPM

b *P* value <0.05 for *t* test vs OBPM

Abbreviations: ABPM, ambulatory blood pressure monitoring; DBP, diastolic blood pressure; HBPM, home blood pressure monitoring; OBPM, office blood pressure measurement; SBP, systolic blood pressure; UAOBPM, unattended automated office blood pressure measurement

TABLE 3 Correlation coefficients between blood pressure values obtained through both measurement methods and the hypertension mediated organ damage parameters

HMOD	Method of blood pressure measurement					
	UAOBPM systolic	OBPM systolic	*P* value[a]	UAOBPM diastolic	OBPM diastolic	*P* value[a]
LVM	r = 0.216; *P* <0.001	r = 0.173; *P* = 0.01	0.26	r = 0.2; *P* = 0.003	r = 0.155; *P* = 0.02	0.24
RWT	r = 0.101; *P* = 0.1	r = 0.1; *P* = 0.15	0.97	r = 0.15; *P* = 0.03	r = 0.135; *P* = 0.047	0.52
LA volume	r = 0.142; *P* = 0.04	r = 0.136; *P* = 0.045	0.88	r = –0.019; *P* = 0.78	r = –0.026; *P* = 0.72	0.7
GLS	R = 0.001; *P* = 0.99	R = –0.032; *P* = 0.64	0.43	R = 0.024; *P* = 0.73	R = 0.002; *P* = 0.97	0.35
IMT	R = 0.179; *P* = 0.009	R = 0.177; *P* = 0.01	0.96	R = 0.05; *P* = 0.47	R = 0.048; *P* = 0.49	0.93
ACR	R = 0.022; *P* = 0.77	R = –0.027; *P* = 0.71	0.98	R = –0.02; *P* = 0.71	R = –0.009; *P* = 0.89	0.64
PWV	R = 0.332; *P* <0.001	R = 0.266; *P* <0.001	0.08	R = –0.023; *P* = 0.75	R = –0.01; *P* = 0.89	0.58

a *P* value for the Steiger Z test

Abbreviations: HMOD, hypertension-mediated organ damage; LA, left atrium; LVM, left ventricular mass; r, Pearson correlation coefficient; R, Spearman rank correlation coefficient; others, see TABLE 1 and 2

Pulse wave velocity A correlation was observed between SBP measured by both methods and PWV (UAOBPM, R = 0.332; *P* <0.001; OBPM, R = 0.266; *P* <0.001). However, no significant correlation was found between DBP and PWV for either method (TABLE 3).

For SBP, ROC curve analysis showed that both methods (UAOBPM and OBPM) demonstrated similar effectiveness in predicting elevated PWV (FIGURE 4). Conversely, the model showed no effectiveness in predicting elevated PWV for DBP measured by either method (FIGURE 4).

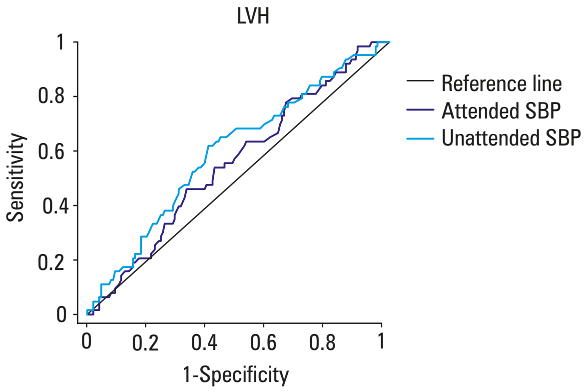
Albumin-creatinine ratio and reduced kidney function No significant correlation was found between the urine ACR and SBP or DBP values, irrespective of the measurement method (TABLE 3).

For DBP, ROC curve model exhibited effectiveness in predicting the presence of elevated ACR, with both methods demonstrating similar accuracy (FIGURE 5). However, the model did not yield significant results for SBP values, regardless of the measurement method (FIGURE 5).

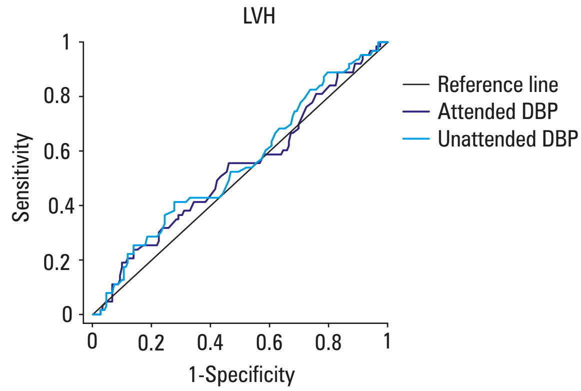
Considering a very low proportion of individuals exhibiting reduced GFR in the studied population (0.9%), an analysis of this HMOD was not pursued.

Comparison of unattended automatic office blood pressure measurement and office blood pressure measurement in predicting hypertension-mediated organ damage Lastly, a comparative analysis was conducted to assess the predictive capacity of 2 office measurement methods, UAOBPM and OBPM, as well as 2 out-of-office measurement methods, HBPM and ABPM. To accomplish this, ROC curve models were developed for each HMOD. In nearly all HMOD cases, no method exhibited superior predictive value. Exclusively in the context of LAE, office measurements demonstrated superior predictive capability in comparison with ABPM (UAOBPM, AUC = 0.608; 95% CI, 0.516–0.701; OBPM, AUC = 0.605; 95% CI, 0.512–0.697 vs ABPM, AUC = 0.501; 95% CI, 0.408–0.595).

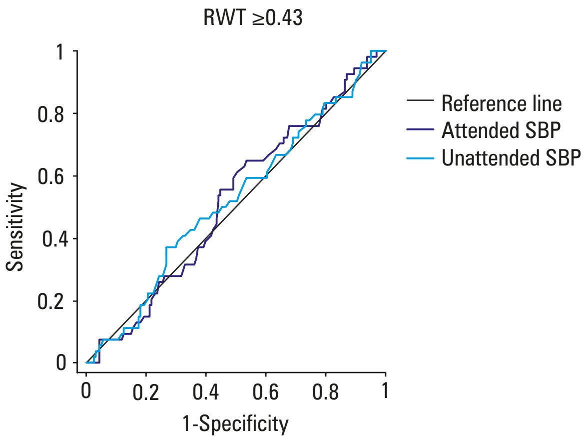
DISCUSSION The objective of this study was to evaluate the predictive potential of unattended BP measurements vs conventional office-based measurements concerning the hypertensive target organ damage. While unattended BP measurements yielded lower values for both SBP and DBP, our findings indicated a high degree of similarity between the 2 methods when it comes to the association of BP values with the presence of HMOD.



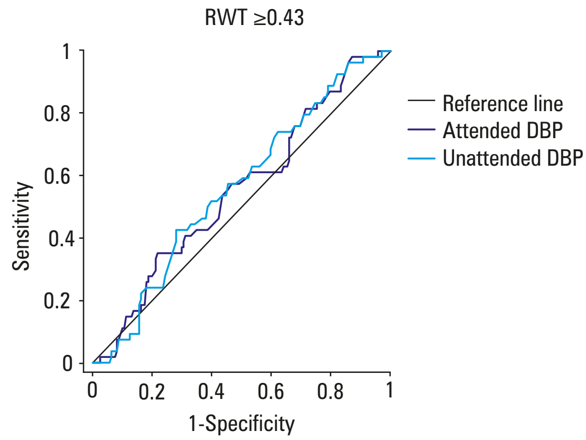
	AUC (95% CI)	*P* value
UAOBP	0.599 (0.516–0.682)	0.09
OBP	0.559 (0.476–0.641)	



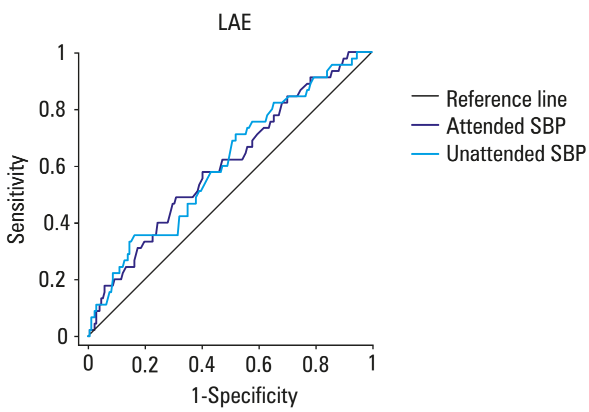
	AUC (95% CI)	*P* value
UAOBP	0.550 (0.465–0.635)	0.35
OBP	0.534 (0.448–0.621)	



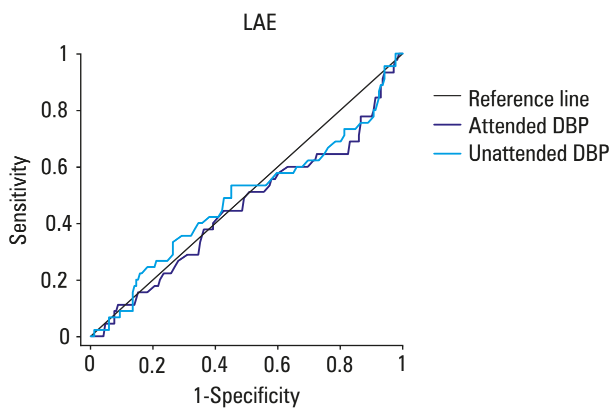
	AUC (95% CI)	*P* value
UAOBP	0.523 (0.434–0.612)	0.88
OBP	0.519 (0.433–0.605)	



	AUC (95% CI)	*P* value
UAOBP	0.562 (0.477–0.647)	0.63
OBP	0.553 (0.466–0.64)	



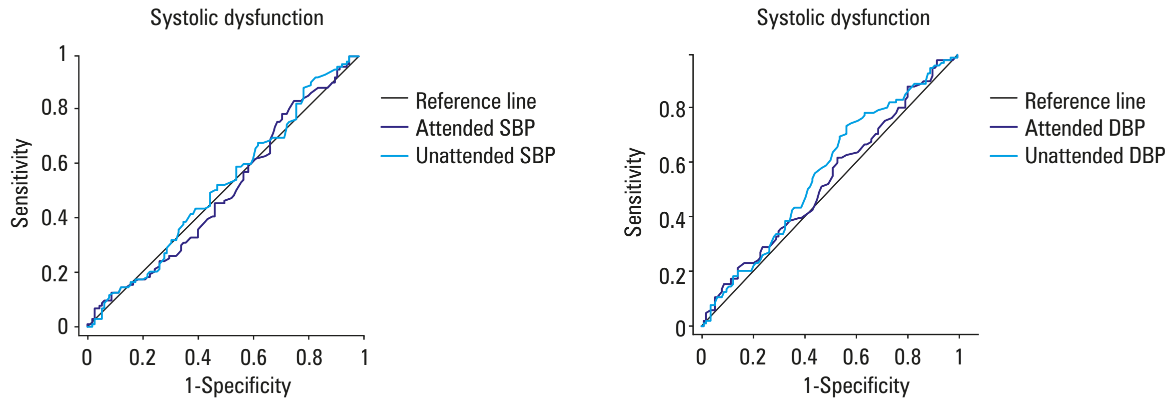
	AUC (95% CI)	*P* value
UAOBP	0.608 (0.516–0.701)	0.85
OBP	0.605 (0.512–0.697)	



	AUC (95% CI)	*P* value
UAOBP	0.484 (0.381–0.587)	0.11
OBP	0.456 (0.356–0.557)	

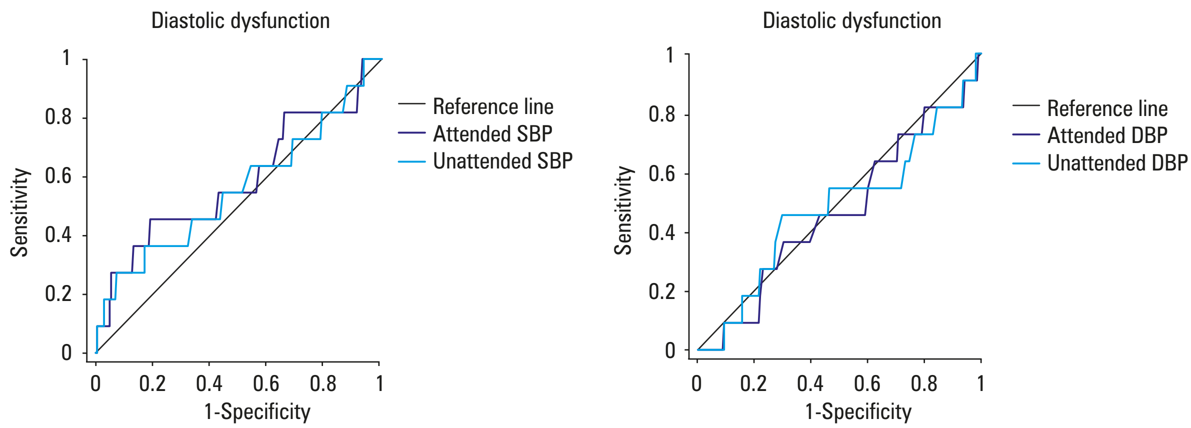
FIGURE 1 Receiver operating characteristic curves for the prediction of left ventricular hypertrophy (LVH), increased relative wall thickness (RWT) or left atrial enlargement (LAE). A comparison of the unattended automated office blood pressure (UAOBP) and OBP measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP)

Precise measurement of arterial BP plays a pivotal role in the accurate diagnosis and effective management of arterial hypertension. There is a growing awareness regarding the inherent inaccuracies associated with BP measurements conducted within clinical settings.[2-5] As a result, current guidelines advocate implementation of out-of-office BP measurements as a means to



	AUC (95% CI)	*P* value
UAOBP	0.517 (0.44–0.595)	0.29
OBP	0.495 (0.418–0.573)	

	AUC (95% CI)	*P* value
UAOBP	0.569 (0.492–0.646)	0.05
OBP	0.539 (0.462–0.616)	



	AUC (95% CI)	*P* value
UAOBP	0.577 (0.352–0.766)	0.43
OBP	0.587 (0.379–0.795)	

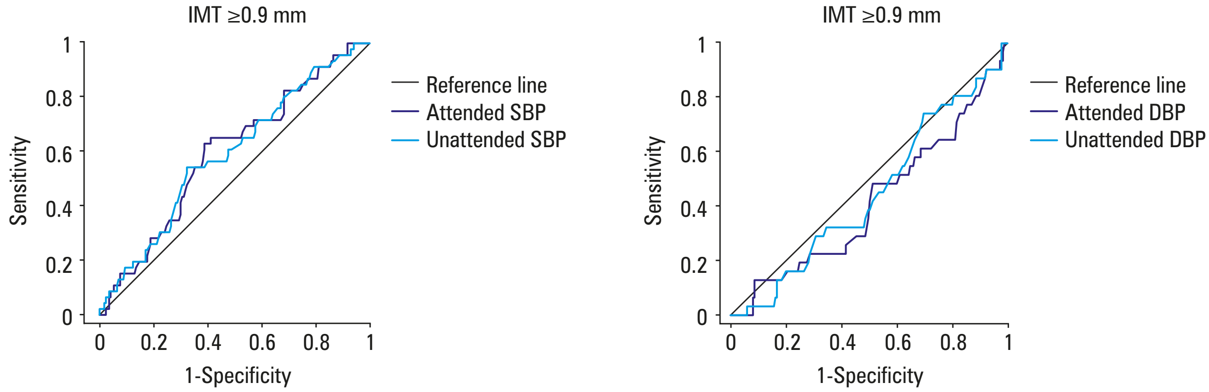
	AUC (95% CI)	*P* value
UAOBP	0.48 (0.28–0.681)	0.74
OBP	0.467 (0.281–0.652)	

FIGURE 2 Receiver operating curves for the prediction of systolic and diastolic dysfunction on echocardiographic examination. A comparison of the unattended automated office blood pressure (UAOBP) and OBP measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP)

circumvent these limitations. This recommendation is endorsed by both the ESH and the International Society of Hypertension (ISH).[6,20]

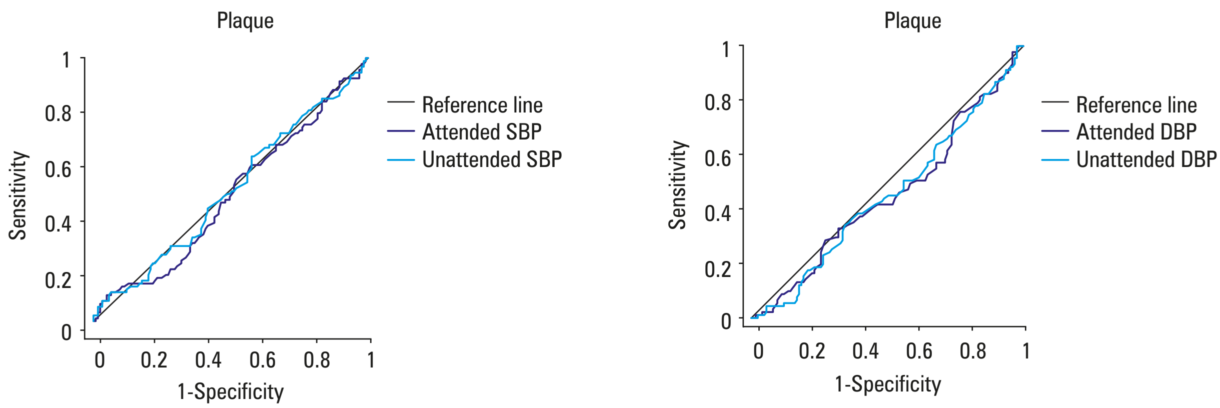
An alternative approach to mitigate measurement errors, initially introduced by Myers et al[7] in 1997, is the method of unattended BP measurements. This technique involves conducting BP measurements in clinical settings, similarly to the conventional method, but without the presence of medical personnel during the actual measurement. Once a measuring device is programmed by the staff, a patient remains alone in an examination room, and the BP measurement is executed after a predetermined period of rest. By adopting this method, several potential inaccuracies commonly associated with clinic-based measurements can be avoided (including errors due to talking during the measurement, insufficient rest time prior to the measurement), and the white-coat effect can be reduced, if not eliminated.[9] This method may be particularly valuable in instances of apparent resistant hypertension, defined as a condition wherein inadequate control of arterial BP does not stem from inappropriate pharmacotherapy selection but rather from inaccuracies in arterial pressure measurement or the pronounced white-coat effect.[21] Nevertheless, the method is not without limitations. It is more time-consuming, requires specialized equipment, often more costly than conventional devices, and necessitates additional dedicated space for conducting the measurements. However, it is important to note that some limitations are context-dependent. For instance, concerning the measurement location, it has been shown that unattended measurements conducted in a hallway of a waiting area adjacent to the examination room are comparably reliable to measurements performed within the examination room itself.[22]

Multiple studies, including ours, have provided evidence that unattended BP measurements consistently yield substantially lower values than conventional clinic-based measurements.[8,9,23] However, some studies, such as a meta-analysis conducted by Kollias et al,[24] suggest that the values obtained from unattended measurements do



	AUC (95% CI)	*P* value
UAOBP	0.636 (0.529–0.755)	0.9
OBP	0.636 (0.526–0.746)	

	AUC (95% CI)	*P* value
UAOBP	0.416 (0.305–0.527)	0.51
OBP	0.446 (0.34–0.552)	

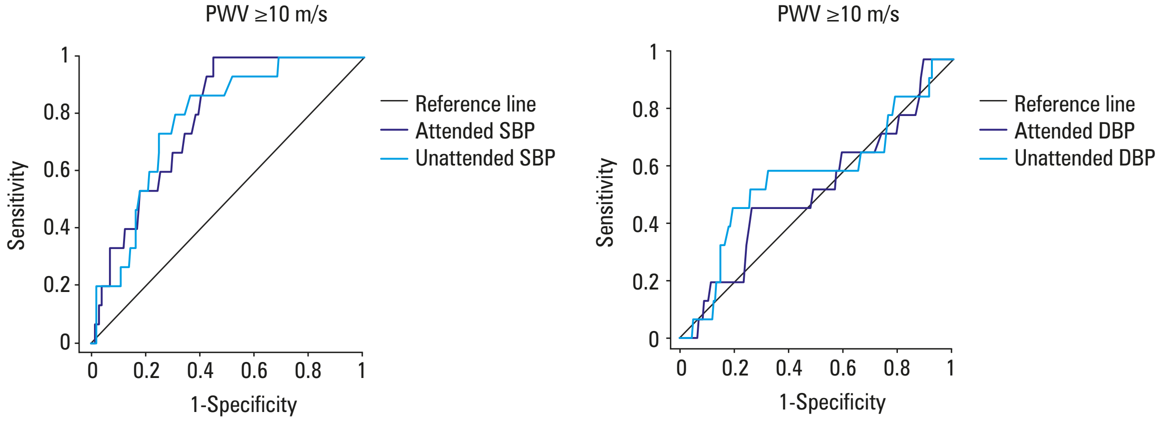


	AUC (95% CI)	*P* value
UAOBP	0.498 (0.419–0.576)	0.33
OBP	0.476 (0.389–0.554)	

	AUC (95% CI)	*P* value
UAOBP	0.451 (0.373–0.529)	0.99
OBP	0.451 (0.373–0.529)	

FIGURE 3 Receiver operating curves for the prediction of increased intima-media thickness (IMT) or presence of atherosclerotic plaque in carotid arteries. A comparison of the unattended automated office blood pressure (UAOBP) and OBP measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP)

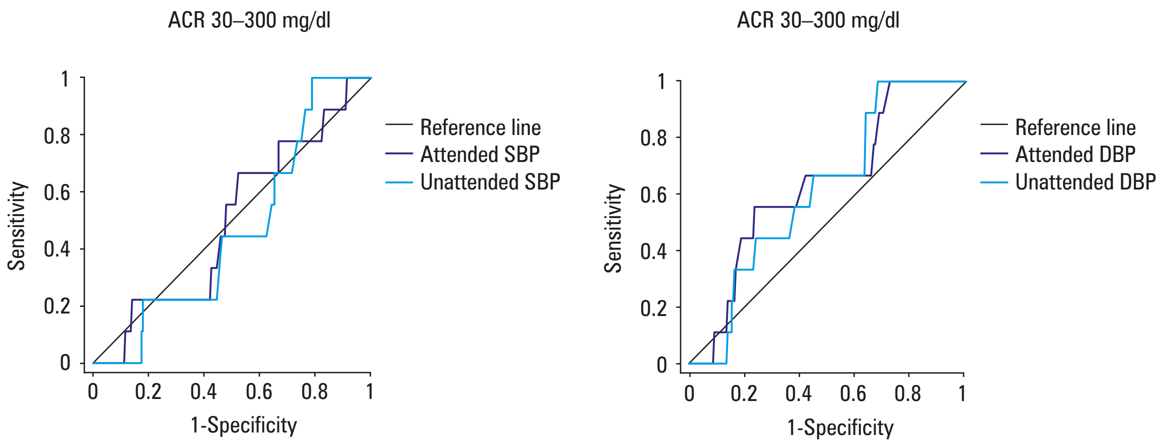
not differ significantly from clinic-based measurements. The observed discrepancies across various studies may be elucidated by calculated means of BP values within the studied populations. For instance, in the SPRINT (Systolic Blood Pressure Intervention Trial),[25] where the baseline mean SBP in both study arms was 139.7 mm Hg, the average disparity between measurement methods was approximately 10 mm Hg for SBP. Conversely, in our ongoing investigation, mean SBP values were 124.7 mm Hg and 128.2 mm Hg, for the unattended and attended measurements, respectively, and the discrepancy between the measurement methods was 3.5 mm Hg. Moreover, our preliminary findings from an unpublished study (personal communication from AO) suggest that absolute BP values, encompassing both systolic and diastolic components, constitute an independent factor contributing to the variations observed between unattended and attended measurements. Another significant factor are the methodologies employed for BP measurements in individual studies. There is currently no standardized measurement protocol. During the measurement, numerous modifiable parameters come into play, including a choice of a device, number of measurements, timing of the measurements, intervals between measurements, inclusion or exclusion of the initial reading, and a specific location where the measurements are conducted (eg, examination room vs a hallway in the waiting area).[26] Nevertheless, it is important to emphasize that adhering to a specific protocol can also mitigate fundamental errors associated with conventional measurements. Consequently, BP values obtained from UAOBPMs appear to exhibit greater objectivity when compared with real-life clinic-based measurements. Presumably due to these considerations, the guidelines issued by the Canadian Hypertension Society have acknowledged the preference for this method of BP measurement over traditional clinic-based measurements. Conversely, both the ISH and the Consensus of the ESH have regarded unattended measurements as exhibiting a higher



	AUC (95% CI)	*P* value
UAOBP	0.776 (0.675–0.876)	0.84
OBP	0.776 (0.698–0.874)	

	AUC (95% CI)	*P* value
UAOBP	0.579 (0.409–0.705)	0.08
OBP	0.531 (0.37–0.692)	

FIGURE 4 Receiver operating curves for the prediction of increased pulse wave velocity (PWV). A comparison of the unattended automated office blood pressure (UAOBP) and OBP measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP)



	AUC (95% CI)	*P* value
UAOBP	0.51 (0.36–0.659)	0.84
OBP	0.518 (0.339–0.697)	

	AUC (95% CI)	*P* value
UAOBP	0.654 (0.52–0.789)	0.79
OBP	0.644 (0.475–0.812)	

FIGURE 5 Receiver operating curves for the prediction of increased albumin-creatinine ratio (ACR) in urine. A comparison of the unattended automated office blood pressure (UAOBP) and OBP measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP)

degree of standardization than the standard clinic-based measurements.[20,27,28] However, there is a limited body of research assessing the prognostic value of unattended measurement, likely contributing to the conservative nature of the ESH guidelines and the absence of specific recommendations pertaining to this particular method of BP measurement.[6]

HMOD holds considerable clinical importance, as it denotes a more advanced phase of hypertensive pathology, may alter the risk stratification of an individual patient, and has the potential to influence therapeutic recommendations, such as initiation of pharmacotherapy.[6,29-32] Moreover, HMOD serves as an indicator of the efficacy of interventions targeting hypertension.[33-35] Numerous studies have been undertaken to compare unattended and attended BP measurements in their ability to predict the presence of HMOD.[11-13,36,37]

Paini et al[12] conducted a comparative analysis of both methods, evaluating their predictive capability in relation to increased PWV. This parameter is a measure of arterial stiffness, with predictive value for cardiovascular risk and mortality confirmed in epidemiologic studies.[38,39] Therefore, the ESH guidelines recognized PWV above 10 m/s as one of the signs of HMOD.[6] In the present study, both methods demonstrated significant predictive capability for the detection of increased PWV. Nevertheless, no method exhibited superiority over the other. The findings of Panini et al[12] are in line with our results, despite greater prevalence of individuals with elevated PWV than in our study population (35.4% vs 6.8%).

The same research team conducted a comparative analysis[36] of both methods with respect to their predictive abilities in relation to complications of hypertension in the context of retinal microcirculation. Consistent with previous findings, neither of the investigated methods exhibited higher effectiveness.

A research team from the University of Brescia also conducted a study[13] to determine if either of the methods exhibited enhanced predictive capability for the presence of LVH and abnormal structure of carotid arteries. A sizeable population consisting of 564 patients was examined, wherein the differences observed in SBP values between UAOPBM and OBPM were greater than in our study (6.5 mm Hg vs 3.5 mm Hg). However, in line with our results, that study also failed to establish superiority of either method in predicting investigated HMOD.

A study by Palomba et al[37] compared correlations between BP values assessed by UAOPBM and OBPM and LVM and the RWT index. Although the sample size in that study was considerably smaller than in ours, similar variations in SBP were observed (4 mm Hg vs 3.5 mm Hg in our work). Furthermore, the general outcome was comparable, as no significant differences were found between the 2 methods in terms of their correlation with LVM and RWT.[37]

Different findings were reported by Campbell et al.[11] Their study examined 176 retired firefighters to assess whether the unattended BP measurement method yields superior predictive capability for increased IMT than conventional office measurements. In a linear regression model, only unattended measurements exhibited the ability to predict IMT, whereas OBPM did not demonstrate such an association. Due to the use of disparate statistical tests, direct comparison of our study findings is challenging. Furthermore, the measurement protocols diverged, with attended measurements employing the auscultatory technique and unattended measurements utilizing an oscillometric device.

To the best of our knowledge, this is the first study to compare 2 methods of BP measurement in predicting the presence of microalbuminuria and systolic and diastolic dysfunction on echocardiographic examination of patients with arterial hypertension. Similarly to observations concerning other types of HMOD, our study did not reveal significant superiority of either of the methods. Additionally, as far as we are concerned, this is the first study to compare these methods with out-of-office approaches, that is, HBPM and ABPM.

A limitation of our study is a relatively low incidence of hypertensive target organ damage in our study group, which can be attributed to effective BP control among the participants and exclusion of individuals with established CVDs. Furthermore, in the context of well-controlled hypertension, BP values exhibit a high degree of convergence, regardless of the measurement method employed. Hence, it appears that any differences between these methods would likely be minimal, and the findings may not be extrapolated to patients with higher BP. Moreover, we did not conduct a power analysis to compare ROC curves. A notable strength of the study is its substantial sample size, meticulously characterized, taking into account a wide range of hypertensive target organ damage types.

Conclusions The findings of the study indicate that both methods of BP measurement exhibit a satisfactory ability to predict the presence of HMOD. Despite significantly lower BP values observed in unattended measurements, this alternative method did not demonstrate superiority over the conventional approach in predicting HMOD. Additional prospective investigations comparing both measurement methods are warranted to further elucidate their comparative effectiveness.

ARTICLE INFORMATION

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CONFLICT OF INTEREST None declared.

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