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Evaluation of Office and Ambulatory Central Blood Pressure and Augmentation Index by Two Methods and Their Changes After Lifestyle or Medical Interventions in Hypertension

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Abstract

Objective Central systolic blood pressure (cSBP) and augmentation index (Aix) can be evaluated in office and also in ambulatory condition, during 24-h monitoring. The aim of our study was to measure cSBP and Aix in the office and in 24-h setting cSBP with two calibration methods and also Aix. Thereafter, we aimed to compare their changes after the initiation of lifestyle modifications or antihypertensive medications.

Methods Office cSBP and Aix were measured with the tonometric PulsePen device (PP-cSBP, PP-Aix, respectively), while 24-h ambulatory cSBP and Aix (24 h-Aix) were evaluated with Mobil-O-Graph. For the calculation of 24-h cSBP both systolic/diastolic and systolic/mean BP calibration methods were considered (24 h-cSBPC1 and 24 h-cSBPC2, respectively). In new hypertensive patients (HT) the measurements were repeated 3 months after the initiation of antihypertensive medication while in white-coat hypertensive patients (WhHT) 12 months after lifestyle modifications.

Results 105 patients were involved including 22-22 HT and WhHT subjects, respectively. PP-cSBP (128 ± 13 mmHg,) was higher than 24 h-cSBPC1 (118 ± 9 mmHg, $p < 0.05$), but equal with 24 h-cSBPC2 (131 ± 11 mmHg). PP-Aix (14 ± 14%) was lower than 24 h-Aix (22 ± 7%, $p < 0.05$). For medical intervention PP-cSBP (Δ16 mmHg) decreased more, than 24 h-cSBPC1 (Δ10 mmHg, $p < 0.05$) and 24 h-cSBPC2 (Δ9 mmHg, $p < 0.05$).

Conclusions Office tonometric and 24 h oscillometric cSBP values differ depending on the calibration. When examining the effect of antihypertensive treatment, the more marked changes in office tonometric cSBP suggests its higher variability compared with 24 h oscillometric central SBP. During follow-up, the two calibration methods of 24 h-cSBP seems not to be interchangeable.

Keywords Central systolic blood pressure, Augmentation index, Tonometry, Oscillometry, 24-h monitoring

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1 Introduction

Cardiovascular (CV) diseases are still the most frequent causes of morbidity and mortality in developed countries. High systolic blood pressure, which is accounted for 10.8 million global deaths in 2019 remains in the leading position among the 20 analyzed CV risk factors [1] and its lowering in hypertensive individuals markedly reduces CV events [2]. Although ambulatory blood pressure monitoring (ABPM) and home blood pressure monitoring are now equally recommended, in the clinical practice the diagnosis of hypertension and the target of treatment is still mainly based on office brachial blood pressure (BP) measurements [3], However, it seems that central BP is more accurately related with hypertension-mediated organ damage than brachial BP, but its measurement is currently not recommended for routine clinical use in guidelines [3, 4]. There are an increasing number of easily available non-invasive devices to measure central hemodynamic parameters in the office and under ambulatory conditions. It is possible now to derive a good estimate of central BP using an automated device with similar appearance to conventional brachial methods. The Mobil-O-Graph device besides that validated for 24-h BP monitoring [5, 6] determines the 24-h central systolic blood pressure (cSBP), using two calibrations. The first employs brachial systolic blood pressure and diastolic blood pressure values (bSBP/bDBP) while the second the mean arterial pressure and diastolic blood pressure values (MAP/bDBP), however the calculated values show differences [7]. In each subject both values can be evaluated during analysis. In addition to central and brachial BP measurements, with Mobil-O-Graph it is also possible to monitor augmentation index (Aix) in 24-h.

Office and 24-h cSBP and Aix values have already been compared with different devices [8], however the changes of their values for different interventions have not been evaluated yet. It would be interesting to measure the changes of these parameters and clarify if with different devices and different settings of measurements the amount of changes of these parameters are also different or not. The aim of our study was to measure bSBP in the office with oscillometry (OMRON M3), cSBP, and Aix in the office with tonometry (PulsePen) and in 24-h setting bSBP, cSBP with two calibration methods and Aix with oscillometry (Mobil-O-Graph). Thereafter, we aimed to compare the changes of the measured parameters after the initiation of lifestyle modifications or antihypertensive medications. In our previous paper, the results of pulse wave velocity changes was already published in the same settings [9].

2 Methods

Our study was a cross-sectional and prospective study, including Caucasian people who required ambulatory ABPM for a variety of reasons: diagnosis of white-coat hypertension (WhHT), masked or resistant hypertension, diagnosis of newly identified hypertension (HT), assessment of the effectiveness of medical intervention 3 months after the initiation of therapy in HT patients, or assessment of the effect of lifestyle changes in WhHT patients after 12 months. The measurements were performed between February 2015 and March 2019 and patients were recruited from the same general practitioner's praxis in Budapest, Hungary. Convenience sampling was used with subsequent inclusion of those patients for whom ABPM was clinically indicated.

In the screening visit blood pressure was measured and participants were invited into the study. In addition, an autoquestionnaire (which was completed without medical assistance at home by the patient) for assessing family and personal history was given to participants, together with a written informed consent. Within 2 weeks of the screening visit, an appointment was set for 7.00 am for the involved patients to receive blood samples from the right arm as well as to have their BP and tonometric central hemodynamic parameter evaluations. In the morning of the clinical measurements, patients were asked to return the completed autoquestionnaires and the signed consent. After blood sampling from the right arm, a 24 h ABPM device (Mobil-O-Graph, I.E.M. GmbH, Germany) was fitted with the cuff placed on the left arm. On the following day, the 24-h ABPM device was brought back, and the patient was given a discussion of the results along with the blood test.

Patients with atrial fibrillation were excluded from the study. WhHT was defined as high office blood pressure in the screening visit (> 140/90 mmHg), and normal blood pressure values during 24 h ABPM (daytime average < 135/85 mmHg, night-time average < 120/70 mmHg, 24 h average < 130/80 mmHg). Hypertension was defined as elevated office blood pressure in the screening visit (> 140/90 mmHg), and elevated blood pressure values during 24 h ABPM (daytime average > 135/85 mmHg, or night-time average > 120/70 mmHg or 24 h average > 130/80 mmHg. Resistant hypertension was defined as blood pressure that remains above 140/90 mmHg in the office despite the use of three antihypertensive medications of different classes, including a diuretic, or as blood pressure that is controlled with the use of more than three drugs [10].

In newly diagnosed hypertensive patients, based on office or ABPM results antihypertensive treatment was personalized according to the guidelines of the European Society of Hypertension [3]. Home blood pressure

monitoring (HBPM) was used to optimize therapy in hypertensive patients 1 week following treatment initiation, and 3 months after the beginning of the therapy, a control ABPM and tonometric central hemodynamic measurement were scheduled.

A 12-month follow-up appointment for an ABPM and tonometric central hemodynamic measurement was scheduled for WhHT patients. Lifestyle changes were advised for WhHT patients based on the ABPM and office BP results. Patients who needed to start receiving medical treatment during this 1 year were excluded from the study.

All patients provided written informed consent prior to participating. The study was approved by the Scientific and Research Ethics Committee of the Medical Research Council Hungarian Ministry of Health (ETT TUKEB 570/2014) and it was carried out in accordance with the tenets of the Declaration of Helsinki.

2.1 Office Blood Pressure Measurement

In the morning of the clinical measurements, prior to the procedure, patients were asked to abstain from smoking and consuming caffeine-containing beverages while continuing to take their regular blood pressure medication. A validated oscillometric blood pressure device (Omron M3) was used to take two BP readings on each arm in sitting position upon arrival and after a 5-min rest. The mean value of the higher side of arms was further taken into the calculation as brachial SBP and DBP and heart rate.

2.2 Office and 24-h Central Hemodynamic Parameter Measurements

Office central blood pressure and Aix were evaluated by the tonometric PulsePen (DiaTecne, Milan, Italy) device. The office cSBP was derived directly by the carotid pulse waveform (PP-cSBP). Aix was measured by the PulsePen software, by identification of the inflection point ("first shoulder") on the carotid pulse signal (PP-Aix). This index is provided by the pressure amplitude following this point divided by the pulse pressure and calculated as a percentage [11]. Systolic and diastolic BP values measured in the supine position were used in these calculations, which were required for calibration after each pulse wave detection. In each subject, two sequences of measurements were performed and their mean was used for statistical analysis. PP-Aix was normalized by the software for the heart rate of 75/min. The 24 h parameters were evaluated by the oscillometric Mobil-O-Graph device. Its BP detection unit was validated according to standard protocols [5, 12]. After the registration of brachial BP, the cuff is kept inflated at the level of DBP for approximately 10 s and records brachial pressure waveforms. Mobil-O-Graph device uses the ARCSolver algorithm with generalized transfer function to evaluate aortic pulse waveform and with a proprietary mathematical algorithm it computes cSBP, cDBP and provides heart-rate adjusted Aix (24 h-Aix) [6, 13]. The cSBP was calculated using different calibrations. In the first setup, peripheral SBP and DBP were used (24 h-cSBPC1), while in the second setup peripheral SBP and mean arterial pressure were considered (24 h-cSBPC2). Both results are available at each patient during data analysis. The device was monitoring the brachial SBP, DBP, and heart rate in every 15 min during the day (from 7 am to 10 pm) and in every 30 min during the night (from 10 pm to 7 am) for 24 h. Measurements were used for the analysis if more than 80% of recordings were valid.

2.3 Statistical Analysis

Descriptive data were expressed as mean ± standard deviation, or median with appropriate interquartile ranges. Kolmogorov–Smirnov test was used to test the normality of the continuous parameters. Pearson correlation coefficient was used to assess correlations. PulsePen and 24 h Mobil-O-Graph measurements were analyzed according to Bland and Altman [14]. Office and 24 h hemodynamic parameters were compared between baseline and follow-up using paired Student's *T*-test or dependent samples Wilcoxon Signed Rank test was used for data failing tests of normality. The magnitude of changes was compared using Student's *t* test. The strength of correlations was compared by Somers' D test. Two-sided $p < 0.05$ was considered to be significant. SPSS 22.0 for Windows (IBM, Armonk, New York, USA) or STATA (StataCorp, College Station, TX, USA) was used for all calculations.

3 Results

One hundred and five patients were involved into the cross-sectional part of the study. ABPM was indicated with the suspect of masked hypertension in 7 cases (6.7%), for the control of antihypertensive therapy in chronic hypertensive patients in 16 cases (15.2%), for the confirmation of resistant hypertension in 12 cases (11.4%), for the diagnosis of new hypertension in 35 cases (33.3%), and for the suspect of WhHT also in 35 cases (33.3%). 22 patients with sustained hypertension and 22 patients with WhHT had control measurements after 3 or 12 months, respectively.

3.1 Cross-Sectional Comparison of PulsePen and Mobil-O-Graph Central BP and Aix

Table 1 shows the baseline demographic and laboratory data of the whole population and in HT and WhHT patients during the first and second measurement.

Table 1 Clinical characteristics of the subjects

	All subjects	HT patients 1	HT patients 2	WhHT patients 1	WhHT patients 2
N (male/female)	105 (62/43)	22 (15/7)	22 (15/7)	22 (10/12)	22 (10/12)
Age, years	48.3 ± 13.2	47.9 ± 13.5	48.2 ± 13.5	45 ± 13.2	46 ± 13.2
Diabetes [*n* (%)]	8 (7.6)	0	0	0	0
CV disease [*n* (%)]	3 (3.8)	0	0	0	0
Current smoker [*n* (%)]	19 (18.1)	5 (22.7)	5 (22.7)	4 (18.2)	4 (18.2)
BMI (kg/m^2)	27.4 ± 3.9	27.3 ± 4.5	26.6 ± 4.3	26.4 ± 4.2	26.6 ± 4.5
Blood glucose (mmol/l)	5.3 ± 0.5	5.9 ± 1.7	5.7 ± 1.3	5.3 ± 0.6	5.3 ± 0.5
GFR-EPI (ml/min/1.73 m^2)	100.1 ± 14	98.2 ± 14.9	98.2 ± 14.9	118 ± 18.4	98 ± 16.5
Uric acid (μmol/l)	344.3 ± 96.3	316.8 ± 93.1	315 ± 93	313 ± 74	312 ± 79.4
Total cholesterol (mmol/l)	5.7 ± 1.1	6.1 ± 1.1	5.8 ± 1.2	5.6 ± 1.7	5.4 ± 1.1
LDL (mmol/l)	3.6 ± 0.9	3.9 ± 1.0	3.7 ± 1.1	3.6 ± 1.5	3.5 ± 0.9
HDL (mmol/l)	1.1 ± 0.4	1.5 ± 0.4	1.4 ± 0.4	1.5 ± 0.4	1.4 ± 0.3
Triglyceride (mmol/l)	1.6 ± 0.6	1.7 ± 1.3	1.6 ± 0.9	1.5 ± 1	1.2 ± 0.6

At hypertensive (HT) and white-coat hypertensive (WhHT) patients, the 1st columns are baseline data, the 2nd columns are follow-up data

The cohort consisted middle-aged subjects (48.3 ± 13.2 years). The occurrence of cardiovascular diseases and diabetes was low in the whole cohort, suggesting a relatively low cardiovascular risk of the population. Table 2 summarizes the office and ambulatory brachial and central blood pressure and Aix data in all subjects and in HT and WhHT patients separately as well.

At hypertensive (HT) and white-coat hypertensive (WhHT) patients, the 1st columns are baseline data, the 2nd columns are follow-up data. PP-cSBP: central systolic blood pressure measured with PulsePen; PP-Aix: augmentation index measured with PulsePen; 24 h-cSBPC1: Mobil-O-Graph 24-h central systolic blood pressure calculated with bSBP/DBP calibration; 24 h-cSBPC2: Mobil-O-Graph 24-h central systolic blood pressure calculated with bSBP/MAP calibration; 24 h-Aix: Mobil-O-Graph 24-h augmentation index. Italic and bold characters demonstrate significant differences ($p < 0.05$) after the follow-up in newly diagnosed hypertensive patients (HT) and in white-coat hypertensive patients (WhHT).

In all subjects, PP-cSBP was lower than office systolic BP ($p < 0.05$), higher than 24 h-cSBPC1 ($p < 0.05$) but was almost equal with 24 h-cSBPC2. PP-Aix was lower than 24 h-Aix ($p < 0.05$). In HT patients both office and central BP values were elevated compared with WhHT patients.

Significant, moderate correlations were found between PP-cSBP and 24 h-cSBP both with the two different calibrations (Fig. 1). The correlation between PP-Aix and 24 h-Aix was significant, but weak. 24 h-cSBPC1 correlated stronger with 24 h-bSBP compared with 24 h-cSBPC2 ($p < 0.001$).

Table 2 Office and ambulatory brachial and central blood pressure values, augmentation index

	All subjects	HT patients 1	HT patients 2	WhHT patients 1	WhHT patients 2
Office systolic BP (mmHg)	141 ± 17	150 ± 15	***129 ± 14***	134 ± 12	***128 ± 17***
Office diastolic BP (mmHg)	85 ± 10	93 ± 10	***77 ± 19***	84 ± 6	82 ± 6
Office heart rate (1/min)	75 (68–86)	84 (70–88)	73 (70–83)	76 (69–85)	76 (67–85)
PP-cSBP (mmHg)	128 ± 13	140 ± 12	***124 ± 12***	122 ± 11	121 ± 13
PP-Aix (%)	12 ± 15	16 ± 15	10 ± 17	11 ± 13	10 ± 12
24-h brachial systolic blood pressure (mmHg)	128 ± 10	137 ± 8	***126 ± 10***	123 ± 6	122 ± 6
24-h brachial diastolic blood pressure (mmHg)	81 ± 9	89 ± 8	***80 ± 10***	78 ± 5	78 ± 5
24-h heart rate (1/min)	73 (68–81)	77 (71–84)	73 (67–81)	76 (70–83)	73 (69–81)
24 h-cSBPC1 (mmHg)	118 ± 9	126 ± 7	***116 ± 8***	114 ± 6	113 ± 5
24 h-cSBPC2 (mmHg)	131 ± 11	137 ± 8	128 ± 10	124 ± 6	124 ± 6
24 h-Aix (%)	22 ± 7	23 ± 8	***21 ± 8***	22 ± 7	22 ± 7

At hypertensive (HT) and white-coat hypertensive (WhHT) patients the 1st columns are baseline data, the 2nd columns are follow-up data. Significant differences between baseline and follow-up date are signed with italic and bold characters

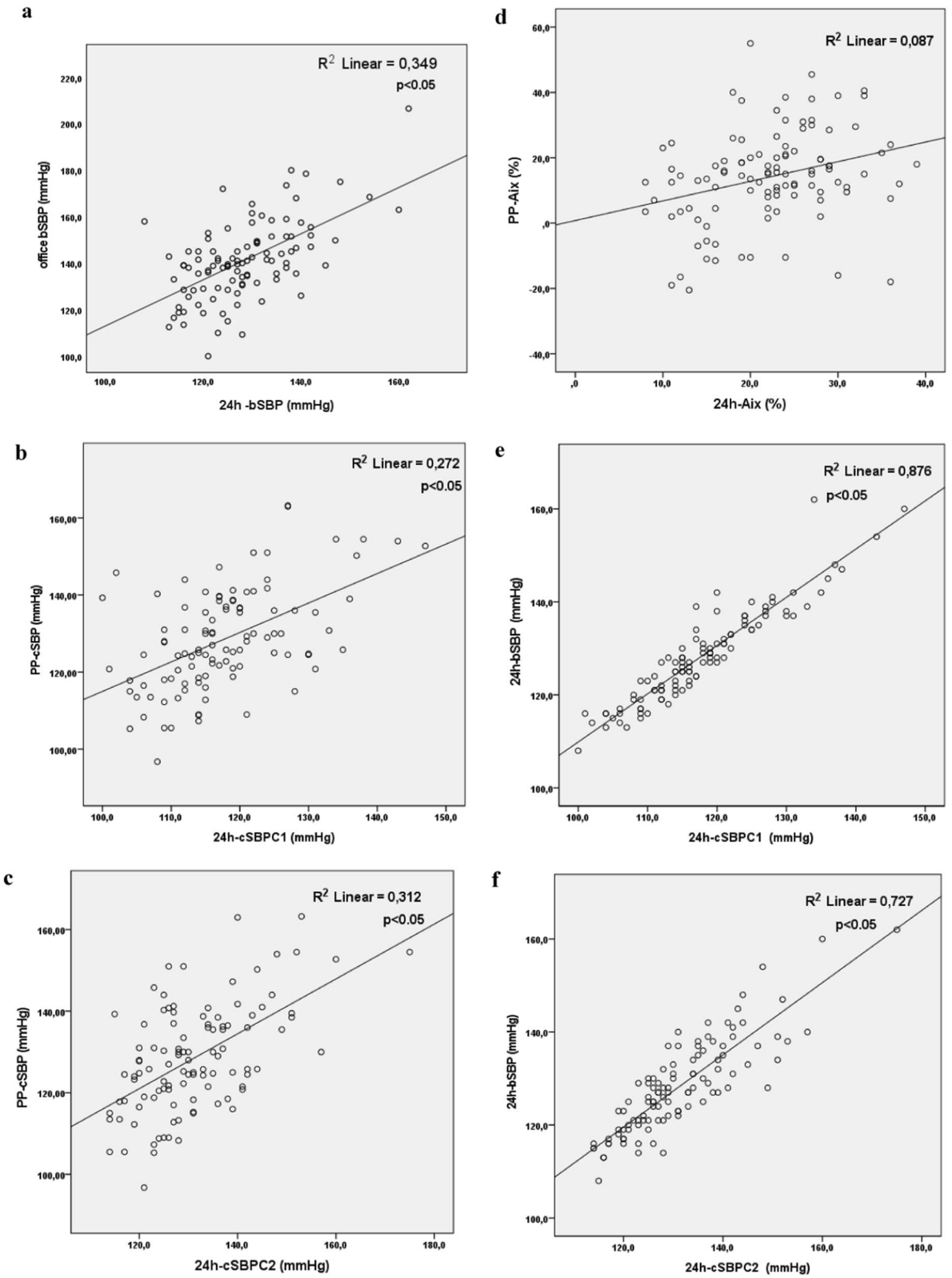

Fig. 1 Correlations between office brachial systolic blood pressure (office bSBP) and 24-h brachial systolic blood pressure (24 h-bSBP) (**a**), between PulsePen central systolic blood pressure (PP-cSBP) and Mobil-O-Graph 24-h central blood pressure with C1 calibration (24 h-cSBPC1) (**b**), between PP-cSBP and 24 h-cSBP with C2 calibration (24 h-cSBPC2) (**c**), between PulsePen augmentation index (PP-Aix) and Mobil-O-Graph 24-h augmentation index (24 h-Aix) (**d**), between 24 h-bSBP and 24 h-cSBPC1 (**e**) and between 24 h-bSBP and 24 h-cSBPC2 (**f**). *N* = 105 in all cases

3.2 Comparison of Hypertensive and White-Coat Hypertensive Patients' Central BP and Aix Changes During Follow-Up

In case of HT patients at the end of follow-up 9 patients were on monotherapy (40.9%) and 13 patients were on dual combination therapy (59.1%). Monotherapies were calcium-channel blocker (CCB) and ACE-inhibitor both in 3–3 cases, beta-blocker in 2 and centrally effective drug in 1 case. Ten patients were on ACE-inhibitor plus CCB, two on ACE-inhibitor plus diuretic and one on ARB plus CCB therapy.

Compared with the baseline, for medical intervention in HT patients, office SBP (Δ21 mmHg) and 24 h SBP (Δ11 mmHg) also decreased ($p < 0.05$, Table 2.). In WhHT patients, only the office SBP (Δ6 mmHg) decreased for lifestyle modifications. In HT patients after 3 months of therapy the magnitude of decreases in office bSBP (Δ21 mmHg) was similar compared to the magnitude of changes in PP-cSBP (Δ16 mmHg) and both were higher than Mobil-O-Graph 24 h-cSBP with the two types of calibrations ($p < 0.05$). PP-Aix changes did not differ significantly from the baseline ($p = 0.099$), while 24 h-Aix changed significantly ($p = 0.04$), but moderately. The correlations between the changes of the different parameters for antihypertensive therapy are shown in Fig. 2. Changes of office and 24-h brachial SBP have shown no correlation. Changes of PulsePen cSBP did also not correlate with 24 h-cSBP neither with C1 nor with C2 calibrations, in line with changes in Aix. In contrast, changes of 24 h-bSBP very strongly correlated with changes of 24 h-cSBP with C1 calibration, while the correlation was weaker ($p < 0.05$), but still strong in case of 24 h-cSBP with C2 calibration.

4 Discussion

In this study, we compared office central blood pressure and Aix with 24-h values and first in the literature, we also compared their changes for medical intervention or lifestyle changes. In the cross-sectional part of our study, PP-cSBP was significantly higher than 24 h-cSBPC1, but equal with 24 h-cSBPC2. PP-Aix was lower than 24 h-Aix. In the prospective part of the study for antihypertensive therapy more pronounced PP-cSBP decrease was present compared with 24 h-cSBP with the two calibration methods, while 24 h-cSBPC1 and 24 h-cSBPC2 decreased with the same rate. PP-Aix change was not significant and 24 h-Aix change was modest. Compared with the normal values 24 h-cSBPC1 and C2 were both elevated in hypertensive patients while it was normal in WhHT ones. For medical intervention, 24 h-cSBPs were both normalized, while in WhHT in response for lifestyle changes they did not change significantly.

Correlations between 24 h-bSBP and both between 24 h-cSBPC1 and 24 h-cSBP-C2 were evaluated in our study. Both correlations were strong, however the correlation with 24 h-cSBPC1 was stronger than with 24 h-cSBPC2. This result is in line with the study of Wassertheurer et al., in which 7409 patients were included and the correlation of office brachial and central parameters were examined [15]. Our finding supports the conclusion of the authors suggesting that as the correlation between brachial SBP and cSBP evaluated with MAP/brachial DBP calibration is less dominant, it might have additional prognostic ability compared to cSBP evaluated with brachial SBP/brachial DBP calibration method.

This conclusion is supported by the prospective part of our study as well. Our hypertensive patients had elevated cSBP (using both calibration methods) at baseline, based on the recently published 24-h reference values of central blood pressure [7], which was normalized with medical treatment. As the effect of antihypertensive medications, 24 h-cSBPC1 changes correlated stronger with 24 h-bSBP changes than the changes of 24 h-cSBPC2. These results suggest that in case of the monitoring of an intervention, the two cSBP calibration methods might not be interchangeable, but further studies are needed to confirm these findings also considering the changes of the central blood pressure values with the different calibrations in relation to the cardiovascular outcome of the patients.

Office bSBP and the tonometric cSBP decreased in higher amount in hypertensive patients and only office bSBP decreased in white-coat hypertensive patients. Changes of office PulsePen cSBP did not correlate with 24-h cSBP changes, while 24-h bSBP and 24-h cSBP changes strongly correlated with both calibration methods. These findings suggest that similarly with office brachial systolic blood pressure, office cSBP can also have higher variability, while 24-h measurements can provide more stable results in both parameters. As in case of brachial systolic blood pressure, ABPM has superiority

(See figure on next page.)

Fig. 2 Effect of antihypertensive medications on the studied parameters ($n = 22$). Correlations between changes of office brachial systolic blood pressure (office bSBP) and 24-h brachial systolic blood pressure (24 h-bSBP) (**a**), between PulsePen central systolic blood pressure (PP-cSBP) and Mobil-O-Graph 24-h central blood pressure with C1 calibration (24 h-cSBPC1) (**b**), between PP-cSBP and 24 h-cSBP with C2 calibration (24 h-cSBPC2) (**c**), between PulsePen augmentation index (PP-Aix) and Mobil-O-Graph 24-h augmentation index (24 h-Aix) (**d**), between 24 h-bSBP and 24 h-cSBPC1 (**e**) and between 24 h-bSBP and 24 h-cSBPC2 (**f**)

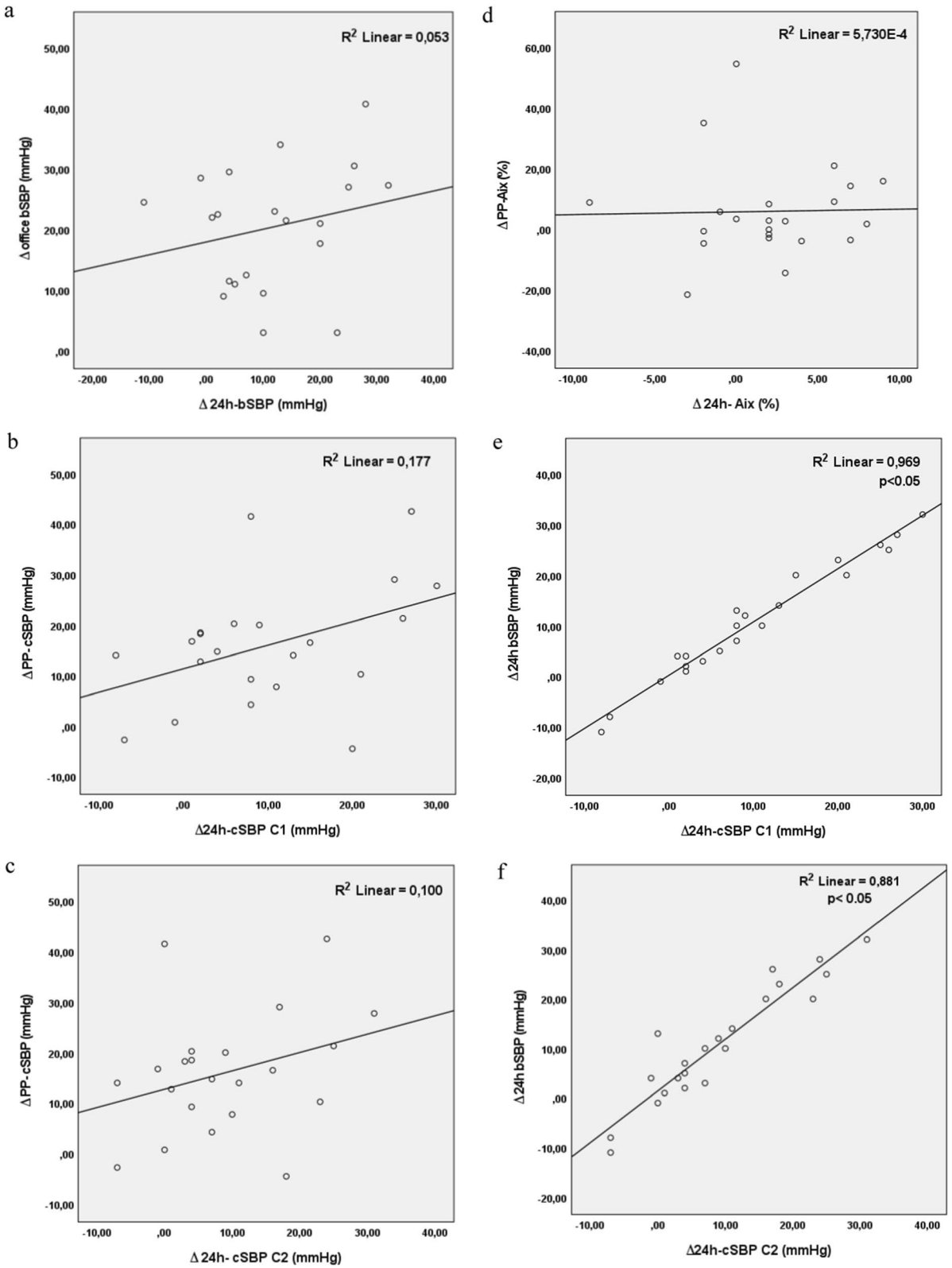

Fig. 2 (See legend on previous page.)

above office measurement in the reproducibility and the prediction of outcome and mortality [3] it might be true for central blood pressure as well, but this hypothesis requires further studies to be confirmed.

In our study, the Aix evaluated in the office by PulsePen differed significantly from the value of 24 h oscillometric Aix. In the study of Luzardo et al. office Aix measured with SphygmoCor provided similar values with 24 h Mobil-O-Graph Aix [8]. We suppose technical reasons in the background of this finding which might contribute to the differences between the two studies. While in case of SphygmoCor, Aix is calculated automatically from radial tonometry pulse curves, during PulsePen measurement carotid artery pulse curve is used, and manual analysis is needed which potentially can lead to more inaccuracy.

During follow-up in the new hypertensive patients, the 24 h-Aix changed significantly, but moderately, while the magnitude of the decrease in PulsePen Aix was only tended to be significant, but because of the high standard deviation of the values it did not reach the level of significance. Our 24 h results are in line with the findings on Weber T et al., who found parallel with significant SBP decrease and significant, but moderate changes in 24 h-Aix (− 0.9%) 3 months after renal denervation in the SPYRAL HTN-OFF MED trial [16]. Regarding office Aix changes, our findings are in line with the study of Zhou et al., who found Aix decrease in the similar magnitude after 8 weeks of bisoprolol therapy (4.02%), but with higher number of patients involved into the follow-up ($n=54$) their results were significant [17]. These results suggest that both office and 24 h-Aix can change into beneficial direction after antihypertensive therapy, but the clinical significance of these moderate changes still must be clarified. Interestingly, the changes of office and 24-h Aix did not correlate at all. An explanation for this observation can be, that Aix is highly dependent on the tone of muscular arteries [18] and during a 24-h measurement higher variability can be expected compared with an office measurement in standard circumstances. The clinical importance of the differences in office and ambulatory Aix changes needs further prospective studies to be clarified.

There are limitations in our study. The generalizability of our findings may be limited because we did not randomly choose our patients. However, as our cohort includes both healthy people and patients with higher cardiovascular risk, it may provide a good representation of the general population. In addition, the low number of patients involved in the prospective parts of our study limited the opportunities in statistical analysis. Moreover, unfortunately office PulsePen and office Mobil-O-Graph central hemodynamic parameters were not comparable in our study as office Mobil-O-Graph measurements were not performed in reliable circumstances. After fitting the device only one measurement was taken in standing position before the release of the patient.

In conclusions, the office tonometric and the 24 h oscillometric central hemodynamic parameters correlate with each other, but the values differ depending on the calibration. When examining the effect of antihypertensive treatment, the more marked changes in office tonometric central SBP suggests its higher variability compared with 24 h oscillometric central SBP. During follow-up, the two calibration methods of 24 h-cSBP seems not to be interchangeable, but more extensive studies are needed to confirm this observation.

Abbreviations

Aix	Augmentation index
BMI	Body mass index
CV disease	Cardiovascular disease
cSBP	Central systolic blood pressure
GFR-EPI	Glomerular filtration ratio calculated using the four-variable Chronic Kidney Disease Epidemiology Collaboration equation
HDL	High density lipoprotein
HT	Newly diagnosed hypertensive patients
LDL	Low-density lipoprotein
PP-Aix	Augmentation index measured with the tonometric PulsePen device
PP-cSBP	Central systolic blood pressure measured with the tonometric PulsePen device
WhHT	White-coat hypertensive patients
24 h-Aix	24-Hour augmentation index
24 h-cSBPC1	24-Hour central systolic blood pressure evaluated with systolic/diastolic BP calibration method
24 h-cSBPC2	24-Hour central systolic blood pressure evaluated with systolic/mean BP calibration method

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Author Contributions
HGy collected data, contributed to data analysis, prepared graphs and tables and wrote the draft of the manuscript; DB, AL and BK measured the patients and collected clinical data; PT sent patients to the study and critically reviewed the manuscript, ZsN-B transmitted patient data into excel, OCs and AT contributed to data analysis and critically reviewed the manuscript, JN planned and supervised the study in all stages and completed the manuscript.

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Declarations

Conflict of interest
The authors declares that there is no conflict of interest regarding the publication of this paper.

Ethics Approval and Consent to Participate
All patients provided written informed consent prior to participating. The study was approved by the Scientific and Research Ethics Committee of the Medical Research Council Hungarian Ministry of Health (ETT TUKEB 570/2014) and it was carried out in accordance with the tenets of the Declaration of Helsinki.

Consent for Publication
Not applicable.

Availability of Data and Materials
Not applicable.

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