Optimal duration and number of readings for unattended automated office blood pressure measurements in patients with type 2 diabetes

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Objective **Unobserved automated office blood pressure (uAOBP) measurement is better correlated to daytime ambulatory blood pressure monitoring (dABPM) than traditional office blood pressure (BP) measurements. However, prolonged uAOBP duration may underestimate BP levels. We aimed to determine the duration of uAOBP that has the lowest proportion of white-coat hypertension (WCH) or masked hypertension (MH) compared with the gold-standard using dABPM in patients with type 2 diabetes (T2DM). Additionally, we examined variables associated with discrepancy between uAOBP and dABPM.**

Methods **A total of 135 patients with T2DM underwent dABPM as well as uAOBP. uAOBP recordings were taken in the sitting position without prior rest for 24 min at 3-min intervals. Hypertension was defined as blood pressure ≥135/85 mmHg. Multiple uAOBP measurement intervals were compared with dABPM by the proportions of patients with WCH, MH, or consistent classification.**

Results **Participants had a mean age of 57.7 years, 38% were female, and 66% used antihypertensive drugs. Average dABPM was 126.9/79.5 mmHg. Extension of uAOBP measurements from 3 to 24 min reduced the proportion with WCH significantly (20.7 vs. 27.4%, $P = 0.012$), with an identical proportion of MH (4.4 vs. 3.7%). Higher BMI, higher urine albumin-creatinine ratio, and higher education were associated with MH, while WCH was associated with older age and early retirement.**

Conclusion **Extending the duration of uAOBP measurements from 3 to 24 min in patients with T2DM increased the proportion of patients with consistent classification by reducing WCH without increasing MH, but clinically relevant individual differences between uAOBP measurements and dABPM remained.** ***Blood Press Monit*** **30: 214–221**

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Keywords: automated office blood pressure measurement, blood pressure, daytime ambulatory blood pressure measurement, masked hypertension, type 2 diabetes, white-coat hypertension

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Introduction

Hypertension is a major risk factor for cardiovascular morbidity and mortality. Hypertension is more prevalent in patients with type 2 diabetes (T2DM) than in the general population, with prevalences of hypertension ranging from 50 to 80% [1]. Optimal blood pressure (BP) control in T2DM reduces risk of cardiovascular disease (CVD) [2], making it crucial to accurately evaluate BP for both diagnosis and monitoring of hypertension.

BP can be measured in various settings, including clinical environments (office BP) and out-of-office locations. Out-of-office BP measurements include ambulatory blood pressure monitoring (ABPM), home BP monitoring, and measurements in other settings such as pharmacies and workplaces. Among these, ABPM, which typically records BP at regular intervals over 24 h, provides separate values for daytime and nighttime BP. Both daytime and nighttime ABPM have been shown to be more reproducible and more closely related to cardiovascular risk than office BP measurements [3,4]. For the sake of convenience, BP is most often measured with conventional office BP, where the BP measurement is attended by a physician or nurse, but this method tends to overestimate BP [5]. An alternative method is unattended automated office blood pressure measurement (uAOBP), in which the patient has repeated BP recordings taken while sitting alone in a quiet room. uAOBP has been shown to be more closely related to daytime ambulatory blood pressure measurement (dABPM) than conventional office BP [5]. White-coat hypertension (WCH) is defined as an elevated office BP with normal ambulatory BP, whereas masked hypertension (MH) refers to a normal office BP with elevated ambulatory BP. Additionally, the white-coat effect (WCE)

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describes a situation where office BP is higher than daytime ABPM but remains within a hypertensive range. The risk of CVD is lower in individuals with WCH compared with those with sustained hypertension. Conversely, the risk of CVD in individuals with MH is estimated to be three times higher than in normotensive individuals [6].

It has been proposed that the optimal duration of uAOBP should be 2–6 min for classification of hypertension consistent with ABPM and that longer durations underestimate BP [7]. However, patients with T2DM have higher BP variability, a lower prevalence of WCH and a higher prevalence of MH compared with people without T2DM [8,9]. Therefore, even though extending uAOBP recordings beyond 6 min could reduce the WCE, it is uncertain whether it would increase the proportion of patients with MH, particularly in those with T2DM. uAOBP has been shown to underestimate BP in patients with high cardiovascular risk [10]. This could potentially misclassify patients who would benefit from treatment, leading to undertreatment.

We hypothesize that extending uAOBP measurements beyond 6 min will reduce the proportion of patients with WCH but increase the proportion of patients with MH. Therefore, the aim of this study was to determine the duration of uAOBP that has the lowest proportion of WCH or MH compared with the gold-standard using dABPM in patients with T2DM. As a supplementary objective, we examined variables associated with discrepancy between uAOBP and dABPM.

Methods

Study participants

The data for this study were derived from a subsample of 163 study participants from the 'Specialist supervised individualized multifactorial treatment of new clinically diagnosed T2DM in general practice' (IDA) study [11] who underwent uAOBP measurements and 24-hour ambulatory blood pressure measurement (ABPM). A total of 1072 study participants in IDA were recruited from the prospective nationwide cohort of the Danish Centre for Strategic Research in Type 2 Diabetes (DD2) [12] if they (1) provided informed written consent, (2) were not diagnosed with type 1 diabetes (defined as age <30 years at DD2 enrollment, fasting C-peptide <300 pM and GAD65-ab >20 IU/mL), (3) had a life expectancy above 2 years, and (4) did not participate in other clinical trials. Data were collected between November 2013 and November 2018.

Of the subsample of 163 participants, 28 were excluded due to less than 20 valid recordings during dABPM [13] ($N = 11$); more than 4 min from attended BP recording to unattended recording ($N = 11$); or interruption of uAOBP before 24 min ($N = 6$), leaving 135 study participants for the analysis.

The IDA study received approval by the Regional Committee on Medical Health Ethics (Region of Southern Denmark S-20120186).

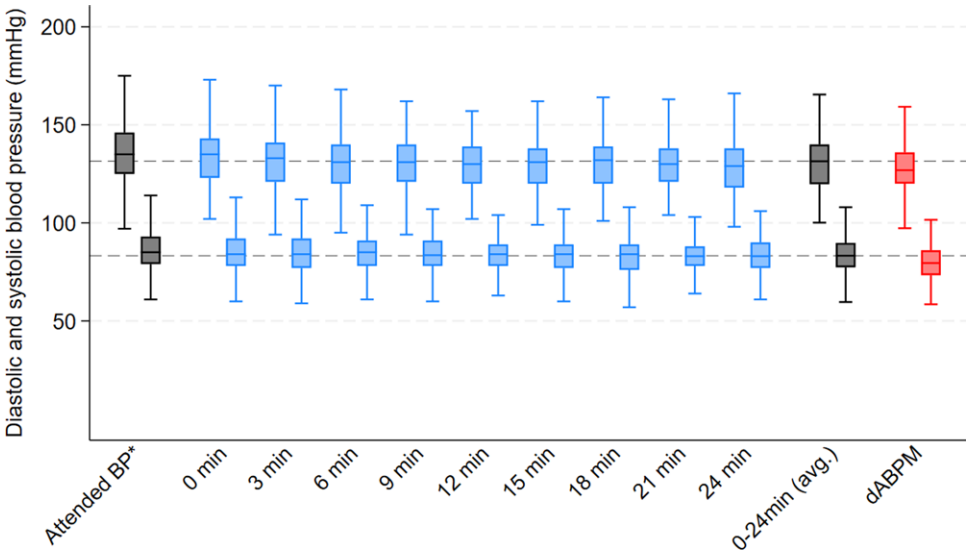
Automated office blood pressure

uAOBP was performed while sitting alone in a quiet room without prior rest. The first recording was attended by a study nurse to ensure valid functioning, after which the room was left. BP recordings were taken every 3 min to ensure proper rest between recordings. After at least 24 min had passed, the BP measurement was discontinued. The same type of BP device (Mobil-O-Graph, I.E.M. GmbH, Stolberg, Germany [14,15]) was used for both uAOBP and dABPM to avoid potential discrepancies arising from device variability. Both the Mobil-O-Graph Pulse Wave Analysis (PWA) Monitor and the Mobil-O-Graph NG Classic Monitor were used for ABPM, with all participants undergoing office measurements using the PWA Monitor, while ABPM was conducted using either the same device or the NG Classic Monitor. The PWA model is technically identical to the NG model but includes an integrated pulse wave analysis system. The device was manually started at an arbitrary time (e.g. 09 : 28), but measurements began at the next whole 3-min mark (e.g. 09 : 30, 09 : 33, 09 : 36). The reference measurement was defined as the average of the first two unattended recordings [e.g. 09 : 30 (time = 0 min) and 09 : 33 (time = 3 min)], with the initial manually started measurement discarded. The time from the first (attended) BP recording to the next (unattended) BP recording was not the same for each patient, being either 1 min (3.7%), 2 min (20.0%), 3 min (45.9%) or 4 min (30.4%) with a mean of 3.0 min (SD: 0.81). For the analysis, it was decided to define the time of the first unattended BP recording as 0 min (see Fig. 1). Measurements were included if at least 7, out of a possible 9, valid measurements were available within the first 24 min.

Ambulatory blood pressure measurement

The 24-h ABPM was performed on the same day as uAOBP. During the ABPM, the participants were instructed to maintain a normal level of activity throughout the day, but to let their arm relax during the BP recording. The device recorded BP every 15 min from 7.00 AM to 11.00 PM and every 30 min from 11.00 PM to 7.00 AM. Only daytime recordings were included in the analysis, and thus, dABPM was assessed as the mean of every valid BP recording from 7.00 AM to 11.00 PM. The ABPM commenced immediately after the participant left the examination room and continued for at least 24 h until the device was returned. Consequently, daytime measurements were derived from both the afternoon of the initial day and the morning of the following day.

Fig. 1



Box plots displaying the distribution of systolic BP (top) and diastolic BP (bottom) for each uAOBP measurement. *Attended BP measurement taken 1–4 min (mean: 3.0 min) before the following uAOBP measurement (see text for details). Box plots display the median (horizontal line within the box), the interquartile range (IQR; box edges representing the 25th and 75th percentiles), and the whiskers (lines extending to the smallest and largest values within 1.5 × IQR from the quartiles). Horizontal dotted lines represent the median of the 0–24 min uAOBP measurements. avg., average; BP, blood pressure; dABPM, daytime ambulatory blood pressure measurement; uAOBP, unattended automated office blood pressure.

Data collection

As a part of the baseline visit of the IDA study [11], a medical interview was conducted to record drug use and medical history. Smoking status, alcohol consumption, education length, and work status were recorded in a questionnaire. A physical examination was performed to measure body weight and height. Clinical measurements of HbA1c, serum creatinine, total-, HDL-, and LDL-cholesterol closest to the baseline visits were used. Blood glucose was obtained from the DD2 blood sample. Estimated glomerular filtration rate (eGFR) was calculated using the Chronic Kidney Disease Epidemiology Collaboration formula based on age, sex, and serum creatinine [16]. Biochemical analyses were conducted at the Department of Clinical Biochemistry, Odense University Hospital, which is accredited by DANAK under accreditation number 06-0221. Information on age and sex was based on the civil registration number (CPR-number). BP monitors were calibrated at baseline and thereafter every 2 years and tested at the manufacturer (I.E.M. GmbH).

Statistical analysis

Data were analyzed using Stata/BE 18.0. We assessed the mean of systolic and diastolic uAOBP measurements of the intervals of 0–3, 0–6, 0–9, 0–12, 0–15, 0–18, 0–21, and 0–24 min and compared them to the mean of the dABPM. For a secondary analysis, we also examined the intervals of 3–6, 3–9, 3–12, 3–18, 3–24, 6–12, 6–18, 6–24, 9–15, 12–18, 12–24, 15–21, and 18–24 min. We examined the ability of each interval to consistently classify patients as above or below the limit of 135/85 mmHg compared with the mean of dABPM by calculating the sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV), area under receiver-operator characteristic curves (AUC), and average-measure intraclass correlation coefficient (ICC). We then defined persons with WCH as persons with uAOBP ≥135/85 mmHg and dABPM <135/85 mmHg and MH as uAOBP <135/85 mmHg and dABPM ≥135/85 mmHg for each interval of uAOBP examined. We compared the proportions of patients with consistent classification, WCH or MH for each uAOBP interval with the mean of BP values from the interval of 0–3 min as reference. Differences in proportion of WCH or MH between intervals were tested by using McNemar's exact test. The interval of 0–3 min was chosen as the reference because it most closely aligns with current uAOBP guidelines [17] (also in line with procedures in the Systolic Blood Pressure Intervention Trial – SPRINT [18]).

Additionally, we evaluated the precision of the uAOBP measurement intervals by examining the proportions of persons with systolic and diastolic uAOBP measurements within 10 mmHg of dABPM, defining persons with WCE as systolic or diastolic uAOBP at least 10 mmHg higher than dABPM and defining persons with MH effect (MHE) as systolic or diastolic uAOBP at least 10 mmHg lower than dABPM.

To describe the difference between uAOBP and dABPM as a function of the BP level, we constructed Bland–Altman plots for the uAOBP intervals 0–3 and 0–24 min.

Table 1 Characteristics of the study participants ($n = 135$), divided in two groups: (1) dABPM <135/85 mmHg and (2) dABPM ≥135/85 mmHg

Variable	dABPM < 135/85 mmHg ($n = 85$)	dABPM ≥ 135/85 mmHg ($n = 50$)	Total ($n = 135$)	*P* value
Age, years	59.3 (11.5)	54.9 (10.0)	57.7 (11.1)	**0.03**
Sex, female	35 (41.2%)	16 (32.0%)	51 (37.8%)	0.29
Smoking status, never smoked	45 (52.9%)	20 (40.0%)	65 (48.1%)	0.15
Diabetes duration, years (median, IQI)	0.85 (0.41; 2.33)	0.65 (0.36; 4.83)	0.83 (0.40; 2.80)	0.97
Previous CVD	12 (14.1%)	8 (16.0%)	20 (14.8%)	0.77
Number of antihypertensive drugs				
None	29 (34.1%)	17 (34.0%)	46 (34.1%)	
1–2	41 (48.2%)	25 (50.0%)	66 (48.9%)	
3–4	15 (17.6%)	8 (16.0%)	23 (17.0%)	0.97
BMI, kg/m²	31.8 (7.3)	34.1 (6.7)	32.6 (7.1)	0.07
urine albumin/creatinine ratio, mg/g	15.4 (24.9)	86.0 (393.8)	41.7 (241.9)	0.11
HbA1c, mmol/mol	50.9 (10.8)	53.8 (11.7)	52.0 (11.1)	0.14
eGFR, mL/min/1.73 m²	87.1 (17.1)	95.6 (17.1)	90.3 (17.5)	**0.01**
Systolic dABPM, mmHg (median, IQI)	123.6 (118.0; 127.4)	140.2 (134.9; 143.7)	126.9 (120.0; 135.9)	**<0.01**
Diastolic dABPM, mmHg (median, IQI)	75.4 (71.4; 80.4)	87.7 (82.6; 91.3)	79.5 (73.3; 86.0)	**<0.01**
Systolic uAOBP 0–3 min (median, IQI)	127.0 (117.8; 135.8)	141.8 (135.0; 153.0)	134.0 (122.5; 141.5)	**<0.01**
Diastolic uAOBP 0–3 min (median, IQI)	81.0 (75.5; 85.5)	91.5 (87.0; 99.5)	84.0 (77.5; 91.5)	**<0.01**
Systolic uAOBP 0–24 min (median, IQI)	125.9 (116.6; 133.7)	139.8 (132.0; 149.3)	131.4 (119.8; 140.0)	**<0.01**
Diastolic uAOBP 0–24 min (median, IQI)	81.2 (75.2; 84.7)	90.5 (84.7; 96.3)	83.2 (77.3; 89.8)	**<0.01**

Values are mean (SD) or number (%) unless otherwise stated. Bold formatting denotes *P* value <0.05.
CVD, cardiovascular disease; dABPM, daytime ambulatory blood pressure measurement; eGFR, estimated glomerular filtration rate; IQI, interquartile interval; uAOBP, unattended automated office blood pressure.

Variables associated with MH and WCH were tested by a chi-square test for categorical variables and continuous variables were tested by an ANOVA test when the mean is reported and by a Kruskal–Wallis test when the median is reported. For analysis of MH, we used patients consistently classified with normal BP by uAOBP as a reference, and for analysis of WCH used patients consistently classified with hypertension as a reference. The variables tested for were age, sex, smoking status, diabetes duration, previous CVD, use of antihypertensive drugs, BMI, HbA1c, urine albumin/creatinine ratio, alcohol consumption, blood glucose, education length, work status, total-cholesterol, HDL-cholesterol, LDL-cholesterol, and eGFR <60 mL/min/1.73 m².

A *P* value less than 0.05 was considered statistically significant.

Results

General characteristics

The participant characteristics are shown in Table 1. Participants had a mean age of 57.7 years, 38% were female, 66% used antihypertensive drugs, and on average had a BMI of 32.6 kg/m² and a dABPM of 126.9/79.5 mmHg. The median duration of T2DM was 0.8 years (interquartile interval, 0.4–2.8 years). Those with hypertension based on dABPM were significantly younger and had a higher eGFR compared with those with normal dABPM.

Optimal uAOBP protocol

Figure 1 shows the systolic and diastolic BP values for each of the nine successive uAOBP recordings as well as the attended office BP recording, the average of uAOBP values from 0 to 24 min and the dABPM. BP values gradually declined from the uAOBP recording at 0 min to the 24-min uAOBP recording, with systolic BP dropping 5 mmHg and diastolic BP 2 mmHg. However, uAOBP values did not recede below dABPM on average, as the mean of the 24-min recording was 129.5/83.1 mmHg and the dABPM 129.2/79.5 mmHg. The mean difference of systolic uAOBP and dABPM was 4.4 mmHg [95% confidence interval (CI), 2.6–6.1 mmHg] for 0–3 min and 2.2 mmHg (95% CI, 0.7–3.7 mmHg) for 0–24 min, and the mean difference of diastolic uAOBP and dABPM was 5.7 mmHg (95% CI, 4.5–6.9 mmHg) for 0–3 min and 4.4 mmHg (95% CI, 3.3–5.5 mmHg) for 0–24 min, respectively (see Supplementary Table 1, Supplemental digital content 1, *https://links.lww.com/BPMJ/A245*).

ICC and AUC were highest for the mean uAOBP from 0 to 24 min (see Supplementary Tables 1 and 2, Supplemental digital content 1, *https://links.lww.com/BPMJ/A245*). The specificity of uAOBP 0–24 min for detection of hypertension was 67.1%, whereas it was 56.5% for 0–3 min ($P = 0.012$) (see Supplementary Table 2, Supplemental digital content 1, *https://links.lww.com/BPMJ/A245*). The sensitivities for detecting hypertension were not significantly different for any of the uAOBP intervals.

Table 2 shows the proportions of patients classified either consistently (with hypertension or normotension), with WCH or MH for each uAOBP interval. Extension of uAOBP from 3 to 24 min increased the percentage of patients with consistent classification from 68.9 to 74.8% ($P = 0.057$). The percentage of patients with WCH was significantly reduced when the uAOBP measurement duration was extended to 24 min compared with 3 min (27.4 vs. 20.7%, $P = 0.012$), while the percentage of patients with MH remained similar (3.7 vs 4.4%).

Table 2 Proportions of study participants ($n = 135$) with either consistent classification, white-coat hypertension, or masked hypertension as measured by uAOBP compared with dABPM (hypertension defined as BP ≥135/85 mmHg)

uAOBP	CC	Diff. CC	*P* value	WCH	Diff. WCH	*P* value	MH	Diff. MH	*P* value
0–3 min	93 (68.9%)	Ref.		37 (27.4%)	Ref.		5 (3.7%)	Ref.	
0–6 min	97 (71.9%)	+3.0%	0.219	34 (25.2%)	−2.2%	0.375	4 (3.0%)	−0.7%	1.00
0–9 min	96 (71.1%)	+2.2%	0.508	35 (25.9%)	−1.5%	0.727	4 (3.0%)	−0.7%	1.00
0–12 min	98 (72.6%)	+3.7%	0.267	32 (23.7%)	−3.7%	0.227	5 (3.7%)	+0.0%	1.00
0–15 min	96 (71.1%)	+2.2%	0.581	32 (23.7%)	−3.7%	0.227	7 (5.2%)	+1.5%	0.50
0–18 min	97 (71.9%)	+3.0%	0.424	31 (23.0%)	−4.5%	0.146	7 (5.2%)	+1.5%	0.50
0–21 min	100 (74.1%)	+5.2%	0.119	29 (21.5%)	−5.9%	**0.039**	6 (4.4%)	+0.7%	1.00
0–24 min	101 (74.8%)	+5.9%	0.057	28 (20.7%)	−6.7%	**0.012**	6 (4.4%)	+0.7%	1.00

P values are calculated using exact McNemar significance probability. Bold formatting denotes *P* value <0.05.
BP, blood pressure; CC, consistent classification as either <135/85 mmHg or ≥135/85 mmHg; dABPM, daytime ambulatory blood pressure measurement; Diff., difference; MH, masked hypertension; Ref., reference; uAOBP, unattended automated office blood pressure; WCH, white-coat hypertension.

Despite an improvement in the proportion of patients with consistent classification of hypertension by extending uAOBP measurement duration, there was a large and clinically relevant intraindividual variation between uAOBP and dABPM. The 95% limits of agreement for systolic BP were (−15.5 to 24.2 mmHg) for 0–3 min and (−15.0 to 19.4 mmHg) for 0–24 min, as visualized in the Bland–Altman plots (Fig. 2). The precision of uAOBP as determined by its ability to consistently classify BP within ±10 mmHg compared with dABPM was improved significantly by 13.3% by extending uAOBP measurement from 3 to 24 min, but even after 24 min, 29.6% of the patients had uAOBP values more than 10 mmHg higher or lower than their dABPM (Table 3). By extending uAOBP measurement from 3 to 24 min, the percentage of patients with WCE defined as uAOBP at least 10 mmHg higher than dABPM was reduced from 34.8 to 24.4% ($P = 0.001$), while the percentage of patients with MHE defined as uAOBP at least 10 mmHg lower than dABPM was reduced from 8.2 to 5.2% ($P = 0.289$) (Table 3).

The results of the analysis of the additional uAOBP intervals in which some of the first BP recordings were discarded are seen in Supplementary Tables 1–4, Supplemental digital content 1, *https://links.lww.com/BPMJ/A245*. Average BP values from sequential triple measurements are displayed in Supplementary Figure 1, Supplemental digital content 1, *https://links.lww.com/BPMJ/A245*. The best numerical results in our cohort were achieved by discarding the 2 first unattended BP recordings, thus taking the average of BP recordings from 6 to 24 min.

To evaluate whether improved agreement with dABPM was driven by extension of the measurement period itself or by the timing of measurement initiation (i.e. after a short rest period), we compared the performance of the 6–12 and 6–24 min intervals. The mean difference in systolic BP compared with dABPM was 1.8 mmHg (95% CI: 0.2–3.4) for the 6–12 min interval and 1.5 mmHg (95% CI: 0.0–3.0) for 6–24 min. The proportion of participants with uAOBP values within ±10 mmHg of dABPM improved only slightly from 65.2 to 68.9%, and the WCE declined from 26.7 to 23.0%. ICC and AUC values for both systolic and diastolic BP were nearly identical.

Variables associated with discrepancy between uAOBP and dABPM

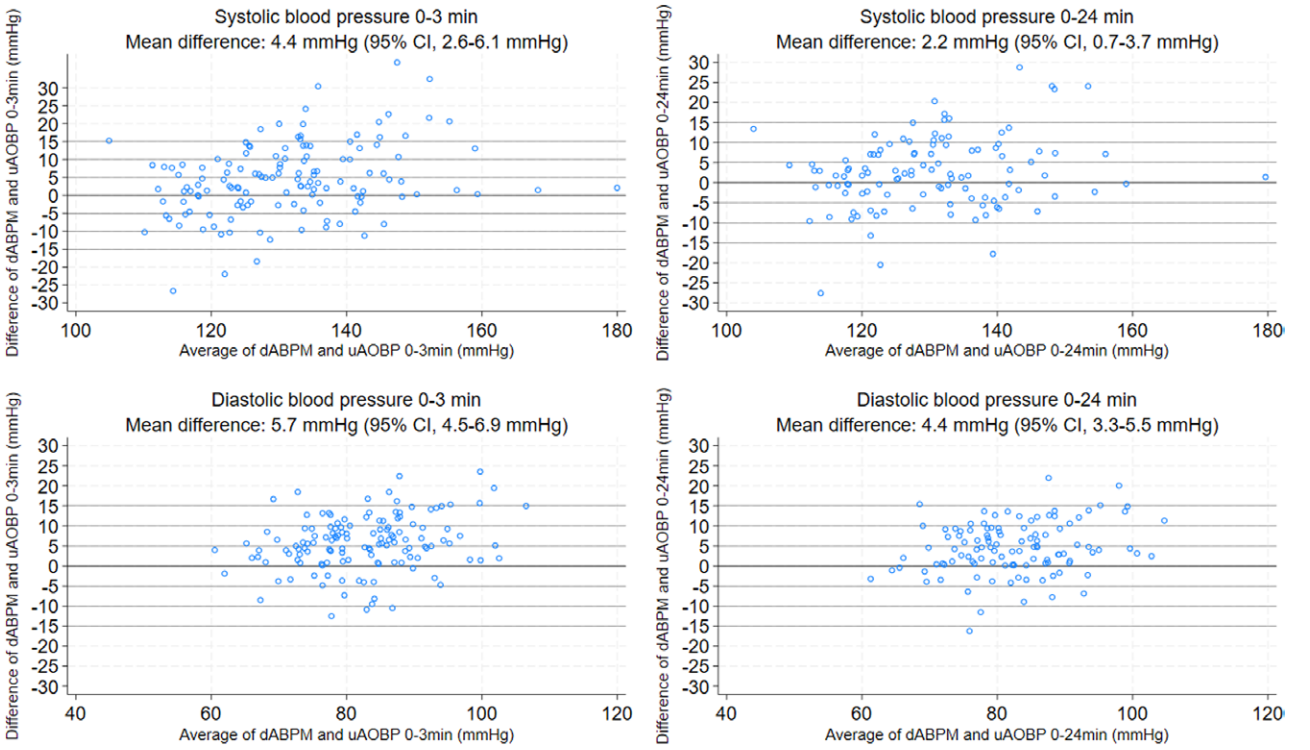
Supplementary Table 5, Supplemental digital content 1, *https://links.lww.com/BPMJ/A245*, shows that patients with WCH were significantly older, more likely to be retired or have retired early due to disability and a median of uAOBP closer to the limit of 135/85 mmHg compared with those with consistent classification of hypertension. Supplementary Table 6, Supplemental digital content 1, *https://links.lww.com/BPMJ/A245* shows that patients with MH had significantly higher BMI, had diabetes for a longer time, higher urine albumin/creatinine ratio, and higher percentage of primary school as the highest level of education compared with those with consistent classification of normal BP.

Discussion

The main finding of this study was that extension of unattended uAOBP measurement in patients with T2DM from 3 to 24 min reduced the proportion of patients with WCH from 27.4 to 20.7% without elevating the proportion of patients with MH. With the extended duration of uAOBP measurement, 74.8% of patients were consistently classified as hypertensive or normotensive compared with dABPM. Additionally, 70.4% had a uAOBP within ±10 mmHg of the dABPM.

In contrast to our study, a previous study by Moore *et al*. [7] among patients in antihypertensive treatment found the optimal duration of uAOBP to be within 6 min with a mean difference between systolic uAOBP and dABPM of 0.004 mmHg after 6 min and an underestimation of BP with further extension. A meta-analysis by Roercke *et al*. [5] examined 19 studies comparing uAOBP and dABPM and found the pooled mean difference to overlap 0 mmHg, but seven studies found uAOBP to be significantly higher than dABPM and six studies oppositely found uAOBP to be significantly lower than dABPM. A possible explanation

Fig. 2



Bland–Altman plots displaying systolic and diastolic uAOBP intervals of 0–3 min and 0–24 min compared with dABPM. CI, confidence interval; dABPM, daytime ambulatory blood pressure measurement; uAOBP, unattended automated office blood pressure.

Table 3 Proportions of study participants ($n = 135$) measured with uAOBP with white-coat effect (uAOBP at least 10 mmHg higher than dABPM), masked hypertension effect (uAOBP at least 10 mmHg lower than dABPM) or consistent classification within ±10 mmHg compared with dABPM

uAOBP	CC	Diff. CC	*P* value	WCE	Diff. WCE	*P* value	MHE	Diff. MHE	*P* value
0–3 min	77 (57.0%)	Ref.		47 (34.8%)	Ref.		11 (8.2%)	Ref.	
0–6 min	81 (60.0%)	+3.0%	0.344	46 (34.1%)	−0.7%	1.000	8 (5.9%)	−2.2%	0.375
0–9 min	84 (62.2%)	+5.2%	0.092	43 (31.9%)	−3.0%	0.289	8 (5.9%)	−2.2%	0.375
0–12 min	87 (64.4%)	+7.4%	**0.021**	42 (31.1%)	−3.7%	0.180	6 (4.4%)	−3.7%	0.125
0–15 min	89 (65.9%)	+8.9%	**0.008**	40 (29.6%)	−5.2%	0.065	6 (4.4%)	−3.7%	0.125
0–18 min	90 (66.7%)	+9.6%	**0.007**	38 (28.2%)	−6.7%	**0.023**	7 (5.2%)	−3.0%	0.289
0–21 min	91 (67.4%)	+10.4%	**0.004**	37 (27.4%)	−7.4%	**0.013**	7 (5.2%)	−3.0%	0.289
0–24 min	95 (70.4%)	+13.3%	**0.001**	33 (24.4%)	−10.4%	**0.001**	7 (5.2%)	−3.0%	0.289

P values are calculated using exact McNemar significance probability. Bold formatting denotes *P* value <0.05.
BP, blood pressure; CC, consistent classification (defined as uAOBP being within ±10 mmHg of dABPM); dABPM, daytime ambulatory blood pressure measurement; Diff., difference; MHE, masked hypertension effect; Ref., reference; uAOBP, unattended automated office blood pressure; WCE, white-coat effect.

for why WCH was not eliminated in our study, compared with the results suggested by the meta-analysis, could be the relatively high proportion of study participants who were not on antihypertensive treatment. Antihypertensive drug use is generally associated with reduced WCH [19]. However, in our study, antihypertensive treatment was not found to be associated with WCH. Another difference in our study was that only patients with T2DM were included, and to our knowledge, this is unique among studies comparing uAOBP and dABPM.

Similar to other studies, we found a small difference in mean BP levels between uAOBP and dABPM after extending the measurement duration [20]. However, there still was a large individual variation between uAOBP and dABPM, suggesting that unattended uAOBP cannot substitute ABPM even if the duration of measurements is extended to 24 min. Additionally, while ICC and AUC were highest for the mean uAOBP over 0–24 min, the AUC for systolic BP increased only slightly from 0.87 (0–3 min) to 0.89 (0–21 min). Though modest, this improvement appears clinically relevant as

it coincides with a reduction in WCH prevalence from 27.4 to 20.7%.

While extending uAOBP measurement duration to 24 min was associated with improved consistency and reduced WCE, our comparison of the 6–12 and 6–24 min intervals suggests that most of the benefit is achieved by delaying the start of measurement to allow a short rest period, rather than through further prolongation of the measurement period. The minimal gain in consistency (3.7 percentage points) and nearly identical ICC and AUC values indicate that a 6–12 min measurement interval initiated after rest may offer a more practical and efficient approach in clinical settings, without compromising diagnostic performance.

Our analysis of patients with MH ($N = 6$) compared with those with consistent classification of normal BP should be interpreted with caution due to the low number of cases. Nevertheless, the analysis cautiously suggests that while a uAOBP below 135/85 mmHg relatively safely rules out hypertension, physicians should consider using ABPM in patients with T2DM with either high BMI or albuminuria. This approach can help accurately identify patients who may require the initiation or intensification of antihypertensive treatment. This is consistent with previous studies [21]. Other studies have found additional variables such as dyslipidemia [22], high alcohol consumption [21], and use of single antihypertensive drugs [22], which we were unable to show.

In a similar manner, our analysis of the variables of patients with WCH ($N = 28$) compared with those with consistent classification of hypertension by uAOBP suggests that use of ABPM should be considered in patients with T2DM and a uAOBP close to the limit of 135/85 mmHg with either high age or a work status as retired or early retirement due to disability. Other studies have additionally found WCH more frequent among women and nonsmokers, which we were unable to confirm [23,24].

Despite expectations that dABPM values would be higher due to daytime activity, they were lower than uAOBP, possibly due to the inclusion of evening or even sleep-period recordings, as a fixed time window was used in the absence of participant diaries. BP variations between work and rest days may also have contributed, though this was not assessed. Additionally, most participants likely took antihypertensive medication in the morning, meaning its full effect may not have been present during uAOBP but influenced dABPM later.

A large number of studies have proved uAOBP to be superior to conventional office BP to detect hypertension and minimize the WCE. However, the SPRINT trial [18] is the only intervention trial examining the effect of BP levels with various outcomes, and this study did not include patients with T2DM. Therefore, though uAOBP correlates better with dABPM than conventional office BP, it remains uncertain if cardiovascular outcomes are improved when antihypertensive treatment is guided by uAOBP. Thus, further research evaluating cardiovascular outcomes based on antihypertensive treatment guided by uAOBP in patients with T2DM would be helpful.

A strength of this study was that the same type of BP device was used to measure both uAOBP and dABPM, and that uAOBP and dABPM were measured on the same day. However, it was a limitation that the time from the first and attended AOBP measurement to the following uAOBP measurement was not the same for each patient, as the BP device during uAOBP by design was set to measure only on minutes dividable by three. Furthermore, with the relatively small number of patients with WCH and MH, our study only had little power to detect variables associated with discrepancy between uAOBP measurements and dABPM on these two parameters. Additionally, we did not exclude the white-coat window, nor were participant diaries available to determine individual wake and sleep times. This may have influenced the accuracy of daytime ABPM classification, as fixed time intervals were used instead of patient-specific circadian patterns. Finally, as we did not adjust for multiple comparisons, some significant findings may have occurred by chance and should be interpreted with caution.

In conclusion, our data demonstrated a benefit in extending uAOBP to 24 min in patients with T2DM, as it reduced the number of patients with WCH. This extension of uAOBP measurement duration can be done safely, as it did not result in underestimating BP or in increasing the number of patients with MH as defined by dABPM. Notably, most of the benefit appears to come from delaying the start to allow a short rest period, as extending the measurement beyond 12 min provided minimal additional improvement, indicating that a 6–12 min interval after rest may offer a more practical and efficient approach without compromising diagnostic accuracy. Despite prolongation of uAOBP, large individual differences between uAOBP measurements and dABPM remained, suggesting that uAOBP cannot substitute dABPM.

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Conflicts of interest

There are no conflicts of interest.

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