Nynke Scherpbier-de Haan, Mark van der Wel, Gijs Schoenmakers, Steve Boudewijns, Petronella Peer, Chris van Weel, Theo Thien and Carel Bakx

Thirty-minute compared to standardised office blood pressure measurement in general practice

Abstract

Background
Although blood pressure measurement is one of the most frequently performed measurements in clinical practice, there are concerns about its reliability. Serial, automated oscillometric blood pressure measurement has the potential to reduce measurement bias and 'white-coat effect'.

Aim
To study agreement of 30-minute office blood pressure measurement (OBPM) with standardised OBPM, and to compare repeatability.

Design and setting
Method comparison study in two general practices in the Netherlands.

Method
Thirty-minute and standardised OBPM was carried out with the same, validated device in 83 adult patients, and the procedure was repeated after 2 weeks. During 30-minute OBPM, blood pressure was measured automatically every 3 minutes, with the patient in a sitting position, alone in a quiet room. Agreement between 30-minute and standardised OBPM was assessed by Bland–Altman analysis. Repeatability of the blood pressure measurement methods after 2 weeks was expressed as the mean difference in combination with the standard deviation of difference (SDD).

Results
Mean 30-minute OBPM readings were 7.6/2.5 mmHg (95% confidence interval [CI] = 6.1 to 9.1/1.5 to 3.4 mmHg) lower than standardised OBPM readings. The mean difference and SDD between repeated 30-minute OBPMs (mean difference = 3/1 mmHg, 95% CI = 1 to 5/0 to 2 mmHg; SDD 9.5/5.3 mmHg) were lower than those of standardised OBPMs (mean difference = 6/2 mmHg, 95% CI = 4 to 8/1 to 4 mmHg; SDD 10.9/6.3 mmHg).

Conclusion
Thirty-minute OBPM resulted in lower readings than standardised OBPM and had a better repeatability. These results suggest that 30-minute OBPM better reflects the patient's true blood pressure than standardised OBPM does.

Keywords
blood pressure; general practice; reproducibility of results.

INTRODUCTION

In everyday practice, blood pressure measurements are often of poor quality, mostly resulting in overestimation of the patient's blood pressure.[1] But, even when performed according to the 'state of the art', blood pressure measurements in the office may not be representative of the patient's true blood pressure status because the phenomenon 'white-coat effect' can introduce an additional level of bias.[2] Overestimation of blood pressure leads to overprescribing of antihypertensive drugs, with avoidable side effects and costs.

Until recently, observer bias and 'white-coat effect' could be eliminated sufficiently only with the ambulatory blood pressure measurement techniques like home blood pressure monitoring and ambulatory blood pressure monitoring (ABPM).[3,4] However, these advantages of ambulatory techniques come with a price. ABPM is not very patient friendly,[5] and is associated with disturbed sleep.[6] Home blood pressure measurements may be inaccurate because of poor measurement technique[7] and report bias.[8] These aspects make ABPM techniques less suitable for routine use in daily practice.

Serial automated blood pressure measurement, without a doctor or nurse present, also has the potential to eliminate observer bias and reduce 'white-coat effect'.[9–12] Compared to ambulatory techniques, this could be used much more easily in routine practice. The results are available during a single consultation, and the procedure appears to be more patient friendly than ABPM. In a recent study, 30-minute automated blood pressure measurement (30 minute OBPM) agreed well with daytime ABPM and classified normotension, 'white-coat hypertension', masked hypertension, and sustained hypertension similarly to daytime ABPM.[13]

The aim of this study was to compare 30-minute OBPM with standardised OBPM in general practice. The level of agreement between both methods was studied and the repeatability compared.

METHOD

Design

A method-comparison study was performed to investigate how 30-minute OBPM agreed with standardised OBPM. As part of the method comparison, a repeatability study of 30-minute OBPM compared to standardised OBPM was carried out.[14]

Participants and setting

The study took place in two general practices of the academic practice-based research network[15] of the Radboud University Nijmegen Medical Centre. Each

N Scherpbier-de Haan, GP, researcher; **M van der Wel**, GP, researcher; **G Schoenmakers**, MD, GP trainee; **C van Weel**, professor of general practice; **JC Bakx**, PhD, GP, researcher, Department of Primary and Community Care; **T Thien**, professor of medicine, Department of Medicine; **PGM Peer**, PhD, biostatistician, Department of Epidemiology, Biostatistics and Health Technology Assessment, Radboud University Nijmegen Medical Centre, Nijmegen, The Netherlands. **S Boudewijns**, MD, resident internal medicine, Tilburg, St Elisabeth Hospital, PO Box 90151, 5000 LC Tilburg, the Netherlands.

Address for correspondence
Nynke Scherpbier-de Haan, Department of Primary and Community care, Radboud University Nijmegen Medical Centre, Huispost 117 elg, 6500 HB, Nijmegen, The Netherlands.
E-mail: n.scherpbier@elg.umcn.nl

Submitted: 1 February 2011; **Editor's response:** 28 February 2011; **final acceptance:** 29 March 2011.

DOI: 10.3399/bjgp11X593875.

How this fits in

Office blood pressure measurement is rarely carried out according to guidelines, introducing bias in blood pressure measurements. In addition, the 'white-coat effect' contributes to unreliable blood pressure readings in up to 20% of patients. A reliable office-based blood pressure measurement method that can overcome both these forms of bias is lacking. Thirty-minute office blood pressure measurement appears to better reflect patients' true blood pressure status, as its readings are lower and more reproducible than those of standardised office blood pressure measurement.

consecutive patient who attended the practice with a main reason for encounter that warranted blood pressure measurement was invited by the practice assistant to participate in the study. Patients gave written informed consent before participation. Exclusion criteria were atrial fibrillation, documented heart valve disease, complete axillary lymph node excision on the right side, and upper arm circumference more than 35 cm. Smoking, diabetes, cardiovascular disease, and medication were recorded.

Blood pressure measurements

Both standardised OBPM and 30-minute OBPM were taken with the same, validated, automated oscillometric device, the Mobil-O-Graph NG (IEM GMBH, Stolberg, Germany).[16] The devices are calibrated annually. Different bladder sizes were used to match the different arm circumferences.

Two researchers were trained to perform the OBPMs according to a detailed protocol (available on request) based on the recommendations of the European Society of Hypertension[17] and the American Heart Association.[18] The key elements of this protocol are listed in Boxes 1 and 2. During visit 1, standardised OBPM was carried out after a 5-minute rest period in the absence of the observer. The measurement consisted of three readings.

Immediately afterwards, 30-minute OBPM followed, consisting of 11 measurements, of which 10 were made in the absence of the researcher. The position of the patient and cuff were not altered. The result of the first measurement of both standardised and 30-minute OBPM was discarded. After 2 weeks, the measurements were repeated by the same researcher in the same room at the same time of the day (visit 2).

To assess whether the measurement order influenced the results, an additional standardised OBPM was performed after the second 30-minute OBPM.

The last noted usual blood pressure measurement was collected, to compare with the study's standardised procedure (Table 1). The last 'usual blood pressure' was not included if there had been a medication change between this

Box 1. Key elements of blood pressure measurement

Key elements of standardised office blood pressure measurement

- No talking
- Temperature in the room 22 degrees Celsius
- Right arm
- Placement of the cuff: 2 cm above antecubital fossa
- Position of patient: sitting, back supported, feet flat on the floor, middle of cuff on level on right atrium
- 5 minutes' rest in the absence of the observer before office blood pressure measurement
- 3 readings with 30 seconds in between, first reading discarded

Key elements of 30 minute automated office blood pressure measurement

- Same position of patient and cuff as in standardised office blood pressure measurement
- 30 seconds after standardised office blood pressure measurement, observer checks first measurement, then leaves the room. Patient stays in same position
- 11 measurements every 3 minutes, first measurement discarded

Box 2. Overview of study method

Time			
Retrospectively	Usual blood pressure		
Visit 1, T = 0	Standardised OBPM	30-minute OBPM	
Visit 2, T = 2 weeks	Standardised OBPM	30-minute OBPM	Standardised OBPM

OBPM = office blood pressure measurement.

measurement and the start of the study.

Sample size

A priori, a difference in blood pressure of 5 mmHg or more was deemed to be clinically relevant. To detect such a difference with a power of 90%, a significance level of 5%, and assuming a standard deviation of the difference (SDD) of 14 mmHg, 82 patients would be needed. Considering a drop-out of 20%, the study aimed to recruit 110 participants.

Statistical methods

All data were registered and analysed in SPSS (version 16). Data were excluded for analysis if there was a change of medication type or doses between the two visits, or if fewer than nine measurements were valid during the 30-minute OBPM.

The level of agreement between standardised OBPM and 30-minute OBPM was assessed by Bland and Altman's approach of difference-against-mean plots.[19] Because the difference increased with increasing blood pressure (positive rank correlation between the standard deviation [SD] and mean of the two blood pressure measurement methods), data were logarithmically transformed.[14] The back-transformed limits of agreement were added to Bland–Altman plots on the original scale.[20] For comparison of means, 95% confidence intervals (CIs) were presented. For evaluation of the repeatability, the mean difference was used in combination with the SDD. The repeatability of the two methods was compared by performing the Wilcoxon signed-rank test on the difference of the SD of the (logarithmically transformed) standardised OBPMs and of the SD of the 30-minute OBPMs.

RESULTS

Participants

A total of 105 patients agreed to participate in the study. Twenty-two patients were excluded from analysis, 10 because fewer than nine measurements of 30-minute OBPM were valid, six because of medication change between the two visits, two because they felt unwell during the measurements,

Table 1. Characteristics of subjects

Characteristic	
Number (male/female)	83 (32/51)
Mean age, years (SD)	62.1 (10.7)
Mean last noted blood pressure in GP record mmHg, (SD) *n* = 78	
Systolic	152.8(16.5)
Diastolic	82.0 (10.0)
On antihypertensive drugs: *n* (%)	69 (83)
Smoking: *n* (%)	10 (12)
Cardiovascular disease: *n* (%)	17 (20)
Diabetes mellitus type 2: *n* (%)	9 (11)

Table 2. Blood pressure results

	Mean blood pressure (SD) in mmHg		Mean difference
	Visit 1	Visit 2	Δ visit 1 — visit 2 (95% CI) [SDD]
Standardised OBPM (*n* = 83)			
Systolic	134.4 (16.4)	128.4 (14.8)	6.0 (3.6 to 8.3) [10.9]
Diastolic	84.1 (10.8)	81.8 (10.7)	2.3 (1.0 to 3.7) [6.3]
30-minute OBPM (*n* = 83)			
Systolic	126.8 (14.1)	123.8 (13.3)	3.0 (0.9 to 5.1) [9.5]
Diastolic	81.6 (10.1)	80.6 (10.5)	1.0 (–0.1 to 2.2) [5.3]
	Mean difference in blood pressure (95%CI) [SDD] in mmHg		
Δ standardised OBPM — 30-minute OBPM (*n* = 83)			
Systolic	7.6 (6.1 to 9.1) [6.8]	4.6(3.2 to 6.1) [6.7]	
Diastolic	2.5 (1.5 to 3.4) [4.5]	1.2(0.3 to 2.0) [3.7]	

Δ = difference. OBPM = office blood pressure measurement. SD = standard deviation. SDD = standard deviation of the difference.

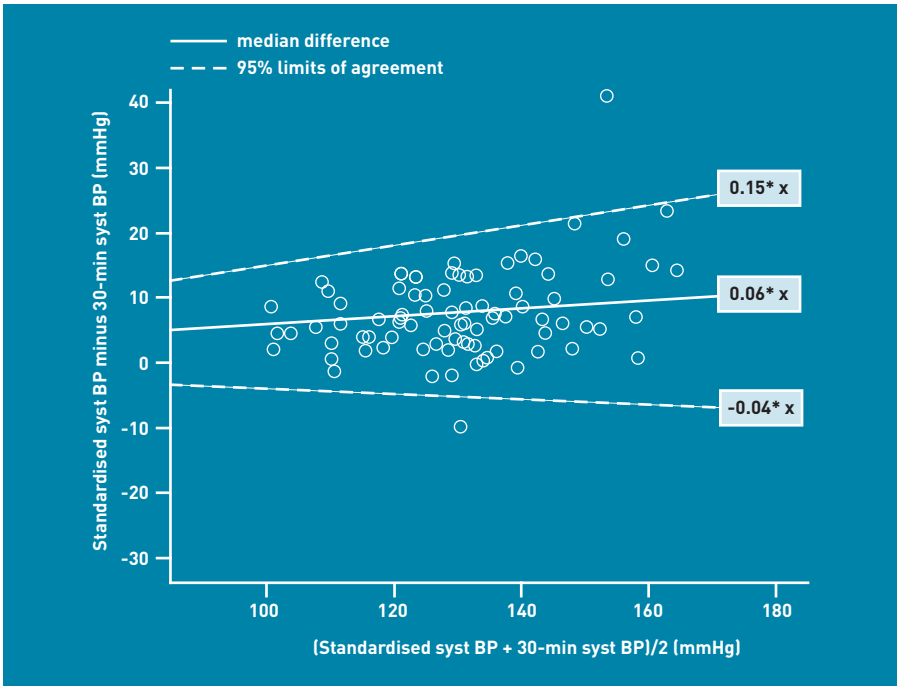


Figure 1a. Comparison of systolic blood pressures. Bland and Altman plot of difference between standardised systolic office blood pressure and 30-minute systolic office blood pressure against their mean (first visit).

Figure 1b. Comparison of diastolic blood pressure. Bland and Altman plot of difference between standardised diastolic office blood pressure and 30-minute systolic office blood pressure against their mean (first visit).

two because they altered the position of their arm during the measurements, and two because they were unable to come for the second visit. The characteristics of included patients are shown in Table 1.

Agreement between 30-minute OBPM and standardised OBPM

Mean 30-minute OBPM readings were significantly lower than standardised OBPM readings, with a mean (absolute) difference of 7.6/2.5 mmHg (Table 2).

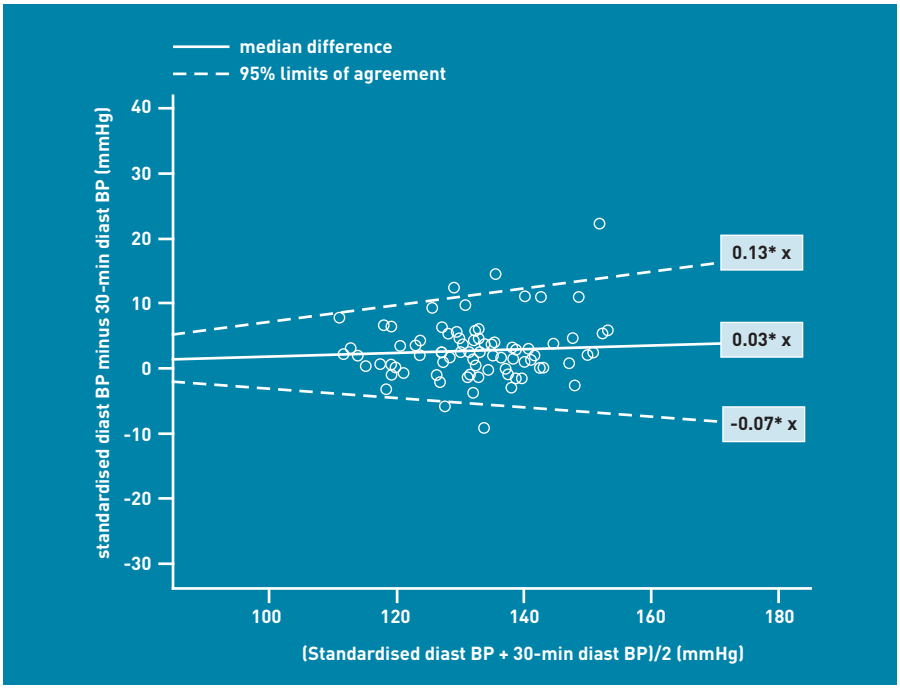


Figure 1a and 1b shows Bland–Altman plots of systolic and diastolic blood pressures during the first visit. These plots show the differences between 30-minute and standardised OBPM against their mean. As the difference increased with increasing blood pressure, the diverging limits of agreement were based on back transformation of results of logarithmically transformed data. The median difference in systolic blood pressure between standardised OBPM and 30-minute OBPM was 6% (95% limits of agreement ranging from –4% to 15%). The median difference in diastolic blood pressure between standardised OBPM and 30-minute OBPM was 3% (95% limits of agreement from –7% to 13%).

Repeatability of standardised and 30-minute OBPM

Table 2 gives an overview of the data on visit 1 and 2 for both measurement methods. The mean difference between the first and second visit of 30-minute systolic OBPM is about half the mean difference of standardised OBPM. In addition, SDDs of repeat 30-minute OBPM were smaller than SDDs of repeat standardised OBPM. The Wilcoxon signed-rank test demonstrated that repeatability was significantly better for 30-minute OBPM than for standardised OBPM ($P<0.01$ for systolic and diastolic blood pressure).

Figures 2a and 2b presents Bland–Altman plots of the repeatability of systolic blood pressure for standardised and 30-minute OBPM respectively. The 95% limits of agreement are wider for standardised than for 30-minute systolic blood pressure (for data on the repeatability of diastolic blood pressure see Table 2; a figure is available on request).

Measurement order

Comparing blood pressures measured by standardised OBPM before (128.4/81.8 mmHg) and after (128.3/82.1) the second 30-minute OBPM (visit 2) demonstrated that the order of measurement did not influence the results (difference (0.1/–0.3 mmHg; 95 % CI = –1.6 to 1.9/–1.2 to 0.6 mmHg) [SDD 7.9/4.0 mmHg]).

DISCUSSION

Summary

In this study, mean 30-minute OBPM readings were significantly lower than standardised OBPM readings, with a difference of 7.6/2.5 mmHg. The repeatability in 2 weeks was better for 30-

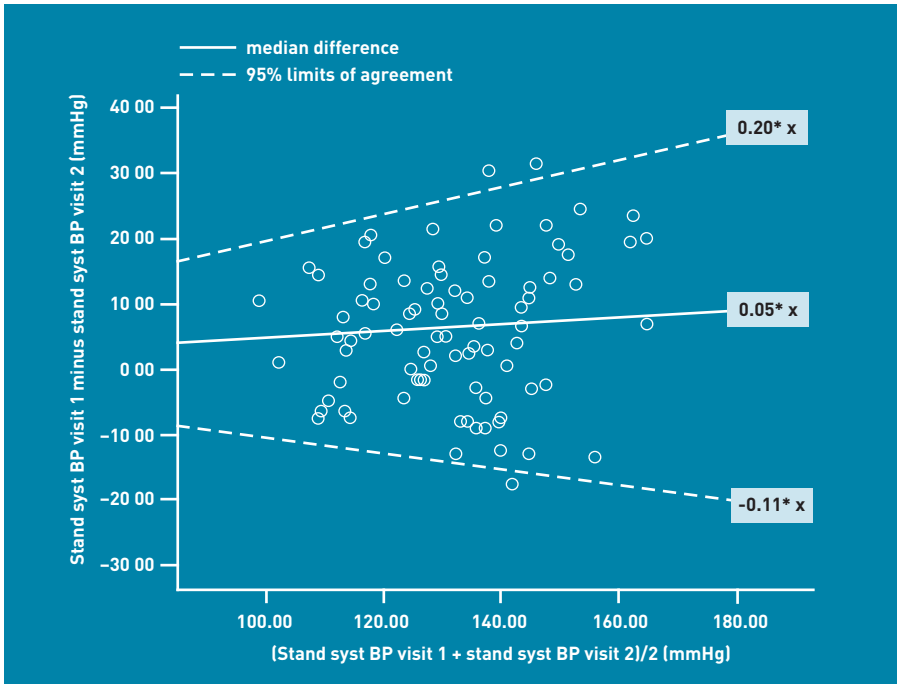
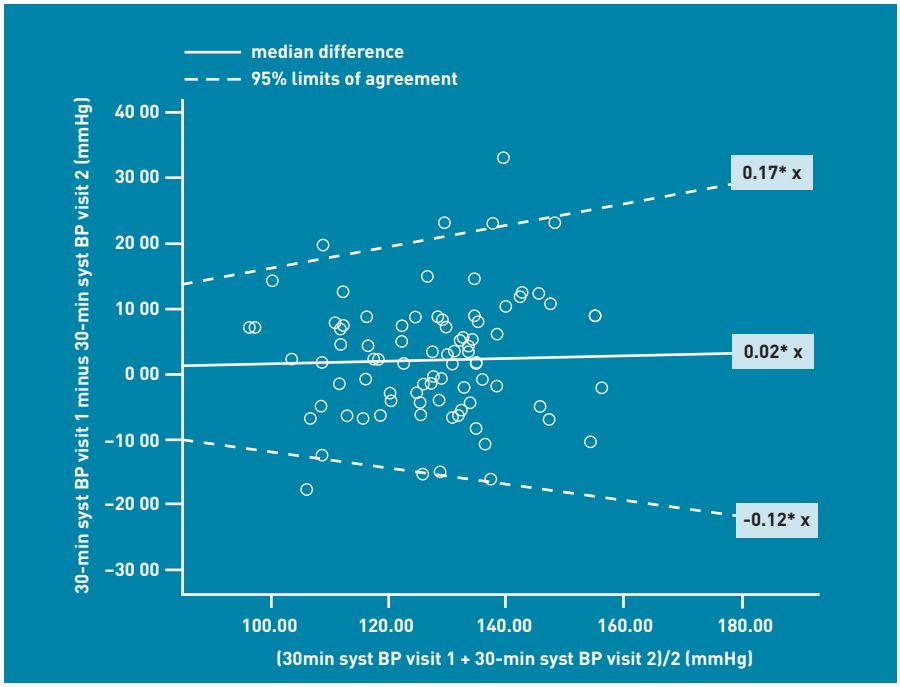


Figure 2a. Repeatability of standardised OBPM. Bland and Altman plots of the repeatability of standardised systolic office blood pressure; difference between visit 1 and visit 2 against the mean.

Figure 2b. Repeatability of 30-minute OBPM. Bland and Altman plot of repeatability of 30-minute systolic office blood pressure; difference between visit 1 and 2 against mean.



minute OBPM than for standardised OBPM: the difference and the SDD in both systolic and diastolic blood pressure between the two visits were significantly lower for 30-minute than for standardised OBPM.

Strengths and limitations

This study has several strengths. It was carried out in a general practice setting, where most hypertension management takes place. It is the first study to perform serial automated OBPM (AOBPM) in general practice, with a common 24-hour ambulatory device. The advantage is that many practices already own one of these devices, and they are likely to be standard equipment in all general practices in the near future. With one type of device (and consequently just one type of software), practices can then run both office and ambulatory measurement protocols. The presentation of data on repeatability is of additive value in judging serial AOBPM in the office.

This study did not randomise the measurement order, which would have been methodologically more accurate. To study whether any time effect would bias the results, a second standardised OBPM was added after 30-minute OBPM. Standardised office blood pressure before and after 30-minute OBPM did not differ, so random measurements appear to have had no significant effect on the results. By introducing 30-minute OBPM, the study aimed to reduce the 'white-coat effect' by leaving the patient alone in a room. The practice setting, which is also part of the 'white-coat effect', may still contribute to a blood pressure rise.

Thirty-minute OBPM takes less time from a healthcare professional than the 8–12 minutes required for a standardised OBPM.[1] However, it takes organisational skills and a spare room to implement 30-minute OBPM in daily practice. Previous research suggests that a duration of 30 minutes may not be necessary.[13] A shorter measurement time may help to overcome organisational problems.

Results were presented both absolutely and relatively. The data in Table 2 were presented in absolute figures. However, it is important to realise that the presented results depend on the height of the blood pressure. Therefore, a relative measure is, strictly speaking, more appropriate. Most data were analysed in this relative form (after log transformation) as can be seen in the Bland–Altman plots, but to facilitate interpretation and enable comparison with other studies, absolute figures are presented in Table 2.

Comparison with existing literature

The study data support abundant evidence on the difference between usual blood pressure measurement and standardised OBPM based on measurement bias.[1,21] In real life, the difference between office blood pressure measurement and 30-minute OBPM will be greater than the difference found in this study, as lack of measurement technique in daily practice will lead to higher blood pressure results.

The mean last noted usual systolic blood pressure was 18 mmHg higher than standardised OBPM (Tables 1 and 2).

With the choice to compare 30-minute OBPM with standardised OBPM, measurement, bias was eliminated as potential (confounding) cause for a difference in blood pressure. It is therefore hypothesised that the presented difference in blood pressure is a result of the reduction of the 'white-coat effect' with 30-minute OBPM. The fact that standardised OBPMs before and after 30-minute OBPM were the same, underlines that a fall in blood pressure during 30-minute OBPM is influenced by the absence of the healthcare professional (and, less so, caused by a long rest period or regression to the mean). Other studies also demonstrated that repeated automated measurements with the patient alone in an examining room give lower results than standardised measurements. Recently, Myers *et al* found a difference of 5.4/2.1 mmHg between automated office blood pressure and conventional manual office blood pressure.[22] These findings, which point in the same direction of lower results of automated measurements, are interesting, as their approach differed from the present one in two aspects: the researchers followed a shorter measurement procedure (10 minutes) and they used routine — not standardised — OBPM as the reference. It would be valuable to establish the repeatability of Myers *et al*'s short procedure. Considering the wide limits of agreement in relation to awake ambulatory blood pressure (limits of agreement –31.9 to 36.6 mmHg,[22] where 30-minute OBPM compared to daytime ambulatory blood pressure revealed limits of –19 to 19 mmHg[13]), one may assume that the repeatability of their short procedure will not be as good as the present longer procedure.

The differences between automated measurements with the patient alone in an examining room and standardised measurements seem to depend on the baseline blood pressure level of the study population; mean automated blood pressure was 142/80 mmHg in an outpatient clinic population (difference 20/5 mmHg)[10] and 115/71 mmHg in an open population study (difference 3/3 mmHg).[23] The mean automated blood pressure of the present study population (134/84 mmHg) was intermediate compared to the above-mentioned studies, with the differences also intermediate. This is in line with the observation in the present study that differences are related to blood pressure level (Figures 1a and b).

To the authors' knowledge, data on the repeatability of any serial AOBPM were lacking until now. This is unfortunate because study of repeatability should be part of every validation procedure.[14] The relevance of repeatability was underlined recently by Palatini *et al*, who reported that ABPM only predicted end-organ damage in subjects with reproducible recordings.[24]

In the absence of data on the repeatability of serial AOBPM, data in the present study were compared with reproducibility studies of 24-hour ABPM. In a study in 508 hypertensive patients,[24] the SDD of 24-hour ABPM was 8.3/6.4 mmHg. Stergiou *et al* reported an SDD of 8.3/5.6 mmHg for 24-hour ABPM; the SDD of the awake 24-hour ABPM was 10.0/6.6.25 In this last-mentioned article, the SDD for clinic blood pressure measurement was 11.0/6.6 mmHg,[25] comparable to the SDD reported in the present study for standardised OBPM (10.9/6.3 mmHg).

This study revealed that 30-minute OBPM had a good repeatability, as the difference between visits 1 and 2 was less than 5 mmHg and the SDD (9.5/5.3 mmHg) was in agreement with above-mentioned studies concerning the repeatability of 24-hour ABPM.

Implications for practice and research

The results of this study demonstrate the potential of 30-minute OBPM to reduce measurement bias and 'white-coat effect' in the office, without the need for ambulatory techniques. Combined with the authors' previous work, a 30-minute OBPM is suggested to be a valid, office-based alternative to daytime ABPM or home blood pressure measurement, in attempting to determine one's true blood pressure status. Meanwhile, the authors realise that 30-minute OBPM cannot replace several, relevant features that are unique for 24-hour ABPM, like measurement of blood pressure variability and nighttime blood pressure.

Myers has already suggested how to implement the use of serial AOBPM in daily practice.[26] He advocates using the same reference value for the diagnosis of hypertension as in home blood pressure monitoring or daytime ABPM (135/85 mmHg). The author's previous finding that 30-minute OBPM outcome agreed well with daytime values of ABPM supports our proposal.[13]

Further research should focus on the comparison of serial AOBPM with home

Funding

This study was not funded.

Ethics committee

Ethics approval was not required (Central Committee on Research involving Human Subjects, Arnhem-Nijmegen, The Netherlands).

Provenance

Freely submitted; externally peer reviewed.

Competing interests

Carel Bakx and Mark van der Wel are performing a trial (NAMI-study, www.clinicaltrials.gov: NCT00457483) with an unconditional grant by Novartis to cover the material costs of the study. All other authors declare that they are independent from funders.

Acknowledgements

We would like to thank the doctors, nurse practitioners, assistants, and patients of the general practices in Berghem and Schaijk (The Netherlands) for their cooperation.

Discuss this article

Contribute and read comments about this article on the Discussion Forum: **http://www.rcgp.org.uk/bjgp-discuss**

blood pressure measurement and on the optimal measurement duration. In addition, implementation studies on cost-effectiveness are required.

In conclusion, 30-minute office blood pressure measurement resulted in lower readings than standardised office blood pressure measurement and had a better repeatability. The favourable repeatability and the lower values of 30-minute OBPM are promising for its value in blood pressure management in general practice.

REFERENCES

1. Campbell NR, Culleton BW, McKay DW. Misclassification of blood pressure by usual measurement in ambulatory physician practices. *Am J Hypertens* 2005; **18(12 Pt 1):** 1522–1527.
2. Pickering TG, Coats A, Mallion JM, *et al.* Blood pressure monitoring. Task force V: white-coat hypertension. *Blood Press Monit* 1999; **4(6):** 333–341.
3. O'Brien E, Coats A, Owens P, *et al.* Use and interpretation of ambulatory blood pressure monitoring: recommendations of the British Hypertension Society. *BMJ* 2000; **320(7242):** 1128–1134.
4. Pickering TG, Miller NH, Ogedegbe G, *et al.* Call to action on use and reimbursement for home blood pressure monitoring: executive summary: a joint scientific statement from the American Heart Association, American Society of Hypertension, and Preventive Cardiovascular Nurses Association. *Hypertension* 2008; **52(1):** 1–9.
5. Little P, Barnett J, Barnsley L, *et al.* Comparison of acceptability of and preferences for different methods of measuring blood pressure in primary care. *BMJ* 2002; **325(7358):** 258–259.
6. Agarwal R, Light RP. The effect of measuring ambulatory blood pressure on nighttime sleep and daytime activity — implications for dipping. *Clin J Am Soc Nephrol* 2010; **5(2):** 281–285.
7. McManus RJ, Glasziou P, Hayen A, *et al.* Blood pressure self monitoring: questions and answers from a national conference. *BMJ* 2008; **337:** a2732.
8. Johnson KA, Partsch DJ, Rippole LL, McVey DM. Reliability of self-reported blood pressure measurements. *Arch Intern Med* 1999; **159(22):** 2689–2693.
9. Gerin W, Marion RM, Friedman R, *et al.* How should we measure blood pressure in the doctor's office? *Blood Press Monit* 2001; **6(5):** 257–262.
10. Myers MG. Automated blood pressure measurement in routine clinical practice. *Blood Press Monit* 2006; **11(2):** 59–62.
11. Myers MG, Valdivieso M, Kiss A. Use of automated office blood pressure measurement to reduce the white coat response. *J Hypertens* 2009; **27(2):** 280–286.
12. Culleton BF, McKay DW, Campbell NR. Performance of the automated BpTRU measurement device in the assessment of white-coat hypertension and white-coat effect. *Blood Press Monit* 2006; **11(1):** 37–42.
13. Van der Wel MC, Buunk IE, van WC, *et al.* A novel approach to office blood pressure measurement: 30-minute office blood pressure vs daytime ambulatory blood pressure. *Ann Fam Med* 2011; **9(2):** 128–135.
14. Bland JM, Altman DG. Measuring agreement in method comparison studies. *Stat Methods Med Res* 1999; **8(2):** 135–160.
15. Van Weel C. Longitudinal research and data collection in primary care. *Ann Fam Med* 2005; **3(suppl 1):** S46–51.
16. Jones CR, Taylor K, Chowienczyk P, *et al.* A validation of the Mobil O Graph (version 12) ambulatory blood pressure monitor. *Blood Press Monit* 2000; **5(4):** 233–238.
17. Mancia G, De Backer G, Dominiczak A, *et al.* 2007 Guidelines for the management of arterial hypertension: The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *Eur Heart J* 2007; **28(12):** 1462–1536.
18. Pickering TG, Hall JE, Appel LJ, *et al.* Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. *Circulation* 2005; **111(5):** 697–716.
19. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986; **1(8476):** 307–310.
20. Euser AM, Dekker FW, le Cessie S. A practical approach to Bland-Altman plots and variation coefficients for log transformed variables. *J Clin Epidemiol* 2008; **61(10):** 978–982.
21. Little P, Barnett J, Barnsley L, *et al.* Comparison of agreement between different measures of blood pressure in primary care and daytime ambulatory blood pressure. *BMJ* 2002; **325(7358):** 254.
22. Myers MG, Godwin M, Dawes M, *et al.* Conventional versus automated measurement of blood pressure in primary care patients with systolic hypertension: randomised parallel design controlled trial. *BMJ* 2011; **342:** d286.
23. Myers MG, McInnis NH, Fodor GJ, Leenen FH. Comparison between an automated and manual sphygmomanometer in a population survey. *Am J Hypertens* 2008; **21(3):** 280–283.
24. Palatini P, Mormino P, Santonastaso M, *et al.* Ambulatory blood pressure predicts end-organ damage only in subjects with reproducible recordings. HARVEST Study Investigators. Hypertension and Ambulatory Recording Venetia Study. *J Hypertens* 1999; **17(4):** 465–473.
25. Stergiou GS, Baibas NM, Gantzarou AP, *et al.* Reproducibility of home, ambulatory, and clinic blood pressure: implications for the design of trials for the assessment of antihypertensive drug efficacy. *Am J Hypertens* 2002; **15(2 Pt 1):** 101–104.
26. Myers MG. A proposed algorithm for diagnosing hypertension using automated office blood pressure measurement. *J Hypertens* 2010; **28(4):** 703–708.