

REVIEW

Standardized home blood pressure monitoring: Rationale behind the 722 protocol

Hung-Ju Lin MD¹ | Heng-Yu Pan MD² | Chen-Huan Chen MD^{3,4} |
Hao-Min Cheng MD^{5,6,7,8} | Yook-Chin Chia MD^{9,10} | Guru Prasad Sogunuru MD^{11,12} |
Jam Chin Tay MD¹³ | Yuda Turana MD¹⁴ | Narsingh Verma MD¹⁵ |
Kazuomi Kario MD¹⁶ | Tzung-Dau Wang MD, PhD¹⁷

¹Cardiovascular, Center and Division of Cardiology, Department of Internal Medicine, National Taiwan University Hospital, Taipei, Taiwan

²Department of Internal Medicine, National Taiwan University Hospital Yun-Lin Branch, Yun-Lin County, Taiwan

³Department of Medicine, National Yang Ming Chiao Tung University College of Medicine, Taipei, Taiwan

⁴Department of Medical Education, Taipei Veterans General Hospital, Taipei, Taiwan

⁵Institute of Public Health and Community Medicine Research Center, National Yang-Ming University School of Medicine, Taipei, Taiwan

⁶Department of Medicine, Division of Cardiology, Taipei Veterans General Hospital, Taipei, Taiwan

⁷Faculty of Medicine, National Yang-Ming University School of Medicine, Taipei, Taiwan

⁸Department of Medical Education, Center for Evidence-based Medicine, Taipei Veterans General Hospital, Taipei, Taiwan

⁹Department of Medical Sciences, School of Medical and Life Sciences, Sunway University, Selangor Darul Ehsan, Bandar Sunway, Malaysia

¹⁰Department of Primary Care Medicine, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia

¹¹Fortis Hospitals, Chennai, Tamil Nadu, India

¹²College of Medical Sciences, Kathmandu University, Bharatpur, Nepal

¹³Department of General Medicine, Tan Tock Seng Hospital, Singapore City, Singapore

¹⁴Department of Neurology, School of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia

¹⁵Asia Pacific Society of Hypertension, Department of Physiology, King George's Medical University, Lucknow, India

¹⁶Division of Cardiovascular Medicine, Department of Medicine, Jichi Medical University School of Medicine, Tochigi, Japan

¹⁷Cardiovascular Center and Divisions of Cardiology and Hospital Medicine, Department of Internal Medicine, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei, Taiwan

Correspondence

Tzung-Dau Wang, MD, PhD, Professor of Medicine, Cardiovascular Center and Divisions of Cardiology and Hospital Medicine, Department of Internal Medicine, National Taiwan University Hospital and National Taiwan University College of Medicine, No.7, Zhong-Shan South Road, Taipei City 100225, Taiwan.

Email: tdwang@ntu.edu.tw

Abstract

Home blood pressure (HBP) has been recognized as a prognostic predictor for cardiovascular events, and integrated into the diagnosis and management of hypertension. With increasing accessibility of oscillometric blood pressure devices, HBP monitoring is easy to perform, more likely to obtain reliable estimation of blood pressures, and feasible to document long-term blood pressure variations, compared to office and ambulatory blood pressures. To obtain reliable HBP estimates, a standardized HBP monitoring protocol is essential. A consensus regarding the optimal duration and frequency of HBP monitoring is yet to be established. Based on the current evidence,

This is an open access article under the terms of the [Creative Commons Attribution - NoDerivs](https://creativecommons.org/licenses/by-nd/4.0/) License, which permits use and distribution in any medium, provided the original work is properly cited and no modifications or adaptations are made.

© 2022 The Authors. *The Journal of Clinical Hypertension* published by Wiley Periodicals LLC.

the “722” protocol, which stands for two measurements on one occasion, two occasions a day (morning and evening), and over a consecutive of 7 days, is most commonly used in clinical studies and recommended in relevant guidelines and consensus documents. HBP monitoring based on the “722” protocol fulfills the minimal requirement of blood pressure measurements to achieve agreement of blood pressure classifications defined by office blood pressures and to predict cardiovascular risks. In the Taiwan HBP consensus, the frequency of repeating the “722” protocol of HBP monitoring according to different scenarios of hypertension management, from every 2 weeks to 3 months, is recommended. It is reasonable to conclude that the “722” protocol for HBP monitoring is clinically justified and can serve as a basis for standardized HBP monitoring.

1 | BACKGROUND

Home blood pressure (HBP) is defined as a form of out-of-office blood pressures self-measured at home, in contrast to office blood pressure (OBP) measured in the clinical setting. Blood pressure fluctuates in response to environmental and pathophysiological stimuli, leading to diurnal, day-to-day and seasonal variations.¹ The variations of blood pressures can be reliably assessed by HBP monitoring. It has been demonstrated that HBP was more closely associated with cardiovascular risks than OBP,² and offered prognostic information independent of OBP.³ There is evidence suggesting that morning HBP was more related to the risk of stroke than evening HBP.⁴ Contemporary guidelines and consensus recommend that both standardized office and out-of-office blood pressures should be assessed to confirm the diagnosis of hypertension.⁵ Incorrect diagnosis of hypertension often occurs if only OBP is assessed, particularly in a non-standardized manner.⁵

Given the increasing affordability of oscillometric sphygmomanometers, HBP measurement is readily accessible, quite affordable; and is able to monitor daily, weekly, and even monthly and yearly variations of blood pressures, as compared to ambulatory blood pressure (ABP) monitoring. ABP monitoring is another form of out-of-office blood pressures measured regularly in a period of minutes for 1 or 2 days. Cumulative evidence has shown that HBP monitoring could be used to guide and improve hypertension management, with or without co-interventions, such as team-based care or telemonitoring.⁶ However, the standardized HBP measurement protocol and follow-up schedule are yet to be established. Factors like how to reliably evaluate HBP and assess HBP variations, how to define a reliable HBP estimate, and the tedious burden with long-term HBP measurement should all be taken into consideration while constructing a protocol for standardized HBP measurement. We herein reviewed the methods of HBP monitoring used and its relations with cardiovascular outcomes in clinical studies to determine how to obtain optimal estimation of HBP. Recommendations from current guidelines and consensus regarding HBP protocols were also summarized. Finally, a practical approach to

standardize HBP measurement for the diagnosis and management of hypertension is suggested.

1.1 | Clinical studies exploring the effectiveness of home blood pressure monitoring

Prior studies have shown that HBP is an independent and better predictor of cardiovascular events than office BP, and is able to guide antihypertensive treatment to achieve better control of hypertension than usual care. As shown in Table 1, the 7-day measurement of HBP was most commonly used to estimate HBP in clinical studies designed to assess the effectiveness of HBP monitoring. In the PAMELA (Pressioni Arteriose Monitorate E Loro Associazioni) study, only two HBP measurements obtained over 2 days were not associated with better predictability of mortality compared to OBP.⁷ HBP measured for at least 3 days appeared to be the minimal requirement to obtain reliable HBP estimation for cardiovascular outcome prediction (Table 1). Most of the studies required HBP measured both in the morning and evening, except the HOMED-BP (Hypertension Objective Treatment Based on Measurement by Electrical Devices of Blood Pressure) study⁸ and the Ohasama study,⁹ where only morning HBP was obtained. To reduce the bias of blood pressure measurement on each occasion, duplicate or triplicate measurements with an interval of 1–2 min were required.¹⁰ Furthermore, it was generally recommended that more than half of total HBP readings supposed to be measured over a week should be obtained to achieve reliable HBP estimation. In the Didima study, duplicate HBP readings in the morning and evening for 3 days were required. At least 6, out of 12 expected HBP measurements, were asked to estimate HBP, by averaging all available measurements.¹¹ The SHEAF (Self-Measurement of Blood Pressure at Home in the Elderly: Assessment and Follow-up) study required the elderly hypertensive participants to take triplicate blood pressure readings in the morning and evening for 4 days. The minimal requirement of blood pressure readings to estimate HBP was at least 15 of 24 expected measurements and at least six readings obtained in the morning and at least

TABLE 1 Clinical studies investigating the effectiveness of HBP monitoring in the control and prognosis of hypertension, ranked by the number of days of HBP monitoring required to obtain HBP estimation

Study	Days of measurement required	Timing		Number of readings per measurement occasion	Intervals between each measurement (minute)	Rest time before HBP measurement (minute)	HBP estimation	
		Morning	Evening				First day discarded	Estimate
Studies requiring only morning readings for HBP estimation								
<7 days of HBP measurements								
HOMED-BP study ^{8,27}	5 days before clinic visit (though HBP was measured every day)	Within 1 h of awakening, before breakfast, before taking antihypertensives	(One evening BP reading at bedtime)	1	-	2	-	Mean of all morning readings
≥7 days of HBP measurements								
TASMINH2 study ²⁸	7 days (the first week of each month)	V	-	2	5	-	-	Mean of all the second morning readings
TASMIN-SR study ²⁹	7 days (the first week of each month)	V	-	2	5	-	-	Mean of all the second morning readings
HOMED-BP study with digital intervention ³⁰	7 days/month	V	-	2	5	-	-	Mean of all the second readings morning
Ohasama study ^{9,31}	28 days	Within 1 h of awakening, before taking antihypertensives	(One evening BP reading at bedtime)	1	-	≥2	-	Mean of all morning readings
Studies requiring morning and evening readings for HBP estimation								
<7 days of HBP measurements								
PAMELA study ⁷	2 days	7 a.m. next morning after clinic visit	7 p.m. at the same day of clinic visit	2	1	-	-	Mean of all measurements
HONEST study ³²	2 days	Within 1 h of awakening, before breakfast, before taking antihypertensives	Just before bedtime	2	-	1-2	-	Mean of all measurements

(Continues)

TABLE 1 (Continued)

Study	Days of measurement required	Timing		Number of readings per measurement occasion	Intervals between each measurement (minute)	Rest time before HBP measurement (minute)	HBP estimation	
		Morning	Evening				First day discarded	Estimate
Didima study ¹¹	3 days	6:30 a.m. - 10 a.m.	5 p.m. - 11 p.m.	2	1	5	-	Mean of all measurements
SHEAF study ³	4 days	8 a.m.	8 p.m.	3	-	5	-	Mean of all measurements (at least ≥ 15 readings, including ≥ 6 morning, ≥ 6 evening readings)
Okumiya K and colleagues ³³	5 days	6 a.m. - 7 a.m.	8 p.m. - 9 p.m.	2	-	5	-	Mean of all the readings
≥ 7 days of HBP measurements								
Niiranen TJ and colleagues ³⁴	7 days	6 a.m. - 9 a.m.	6 p.m. - 9 p.m.	2	-	2	-	Mean of all measurements
THOP trial ³⁵	7 days just before clinic visit	6 a.m. - 10 a.m.	6 p.m. - 10 p.m.	3	-	5	-	Mean of all measurements
Finn-Home study ²	7 days	6 a.m. - 9 a.m.	6 p.m. - 9 p.m.	2	2	10	-	Mean of all measurements
HOMERUS study ³⁶	7 days just before clinic visit	V	V	3	-	≥ 5	-	-
TASMINH4 trial ⁶	7 days (the first week of each month)	V	V	2	-	-	-	Mean of all measurements
J-HOME study ³⁷	2 weeks	Within 1 h of awakening, before breakfast, before taking antihypertensives	Just before bedtime	1	-	2	-	Mean of all measurements
Shimbo D and colleagues ³⁸	6 days/week for 10 weeks	4 days: morning; 2 days: mid-morning	4 days: evening; 2 days: mid-afternoon	3	-	-	-	Mean of all measurements

Abbreviations: ABP, ambulatory blood pressure; BP, blood pressure; CV, cardiovascular; Finn-Home, Finnish home BP monitoring; HBP, home blood pressure; HOMED-BP: Hypertension Objective Treatment Based on Measurement by Electrical Devices of Blood Pressure; HOMERUS: Home versus Office Measurement, Reduction, of Unnecessary treatment Study; J-HOME, Japan Home versus Office Blood Pressure Measurement Evaluation; OBP, office blood pressure; PAMELA, Pressioni Arteriose Monitorate E Loro Associazioni; SHEAF: Self-Measurement of Blood Pressure at Home in the Elderly: Assessment and Follow-up; TASMINH2, Telemonitoring and Self-Management of Hypertension Trial; TASMINH4, Telemonitoring and/or self-monitoring of blood pressure in hypertension; TASMIN-SR, Targets and Self-Management for the Control of Blood Pressure in Stroke and at Risk Groups; THOP: Treatment of Hypertension Based on Home or Office Blood Pressure.

-: indicated "not available" or "none."

6 readings obtained in the evening.³ Taken together, given that blood pressure measurements on the first day are generally discarded as recommended in most guidelines/consensus, a minimum of 4 consecutive days of HBP measurements, with duplicate measurements on 2 occasions a day, is required to obtain HBP estimation with a sufficient prognostic value.

1.2 | Clinical studies exploring the optimal protocol for home blood pressure monitoring

The optimal duration of HBP measurement is influenced by how many times BP readings are taken each day. In general, both morning and evening HBP measurements taken on a consecutive of at least 3 days, if first-day readings are not discarded, are required to derive reliable HBP estimates for the diagnosis of hypertension and cardiovascular risk prediction.^{12–14} While blood pressure measurements taken over a consecutive of 7 to 14 days are needed if HBP is taken only in the morning (Table 2).^{15,16} In the IDH (Improving the Detection of Hypertension) study, a community cohort of 316 adults not treated with antihypertensive medications were asked to measure morning and evening HBP for 14 days to determine the optimal number of measurements needed for reliable HBP estimations. The results revealed that, for diagnosis of hypertension, HBP estimates derived from ≥ 3 -day consecutive measurements were enough if one to two morning and one to two evening readings were obtained daily, while 4 or ≥ 5 days were needed if only morning readings or evening ones were obtained, respectively.¹⁴ The IDHOCO (International Database of HOme blood pressure in relation to Cardiovascular Outcome) study combined individual participant data from the Ohasama, Finn-Home, and Tsurugaya cohorts, and used the first morning HBP readings to assess the optimal number of HBP measurements to obtain reliable HBP estimation.¹⁵ It was found that a minimum of 7-day HBP measurements was required to achieve an optimal agreement of blood pressure classifications by OBP with the κ coefficient of $\geq .9$.¹⁵ Similarly, the Ohasama study showed that ≥ 14 -day single morning HBP measurement was needed to reliably predict the stroke risk.¹⁶

1.3 | Guidelines and consensus recommendations: the “722” protocol for standardized home blood pressure monitoring

As outlined in Tables 3 and 4, most current guidelines and consensus suggest the 7-day HBP measurement schedule, consisting of 2 morning and 2 evening readings each day—i.e., the “722” protocol, is optimal for the diagnosis and management of hypertension, although 3 to 5-day measurements were at a minimum. Morning HBP is recommended to be measured within 1 h after awakening, and before taking medications, breakfast, and vigorous physical activity. The timing of evening HBP measurement is subject to the time interval between taking supper and going to bed. Evening HBP is recommended to be measured before going to bed if the time interval is more than 2 h; oth-

erwise, is measured before taking supper. To mitigate the measurement bias which occurs with higher probability at the beginning of a measurement stint,¹⁰ it is recommended that duplicate or triplicate HBP readings should be taken per measurement occasion, and that the first-day measurements could be excluded from HBP estimation. Although the accuracy of oscillometric blood pressure devices remain doubtful in the presence of atrial fibrillation, it has been reported that the accuracy of systolic blood pressure could be acceptable, rather than that of diastolic blood pressure,¹⁷ especially if the mean of triplicate measurements is used.¹⁸ Given that systolic blood pressure is more prognostically predictive than diastolic blood pressure, and that the auscultatory method of blood pressure measurement could fail owing to muffled Korotkoff sounds, the Taiwan consensus for HBP measurement recommends that ≥ 3 repeated measurements could be plausible in the presence of atrial fibrillation.¹⁹ Given the prognostic impact of morning HBP surge has been recognized,²⁰ averages of morning and evening HBP measurements should be separately considered.^{19,21}

Prior studies showed that inadequate rest before BP measurement could lead to biased BP estimation.²² Because it has been shown that roughly 50% of individuals with their systolic BP stabilized within 5 min after a sitting rest in the clinical setting,^{23,24} most current guidelines recommend at least 5-min rest before each BP measurement occasion (Tables 3 and 4). However, recent studies showed that less than 5-min rest, even without rest, might be acceptable if OBP was estimated using triplicate BP readings obtained at a 1-min interval.^{25,26} It has been concerned that too much rest could make HBP like automated OBP, probably leading to underestimation of usual BP. Provided that home setting is less stressful than clinical setting, shorter than 5-min rest might be plausible if HBP estimates are derived using repetitive BP readings on each measurement occasion.

1.4 | The follow-up schedule for home blood pressure monitoring

For patients with well-controlled hypertension, 1 to 2-day measurements with duplicate readings per occasion on a weekly or monthly basis are generally recommended. Given the evidence of above-mentioned clinical studies and clinical guidelines and consensus recommendations, a comprehensive HBP follow-up schedule, based on blood pressure classifications and status of hypertension management was provided in the 2022 Taiwan Hypertension Guidelines (Figure 1).¹⁰ In general, if blood pressure is not under control, the “722” protocol should be conducted more frequently. For well-controlled hypertensive patients, the 7-day consecutive HBP measurement is recommended to be conducted every 3 months.

2 | CONCLUSIONS

While the reliability of HBP estimation is weighed against the long-term burden of repetitive HBP measurements, it is reasonable to conclude that the “722” protocol for HBP measurement is clinically

TABLE 2 Clinical studies exploring the optimal HBP protocol for diagnosis of hypertension and cardiovascular risk prediction, ranked by the number of days of HBP monitoring required to obtain HBP estimation

Study	HBP measurement protocol					Estimate	Study results
	Study objective	Each day	Time interval between each measurement (minute)	Rest time before HBP measurement (minute)	First day discarded		
HBP estimation based on only morning readings							
IDHOCO study ¹⁵	To determine optimal number of days for HBP measurement in 4802 adults from two Japanese (Ohasama and Tsurugaya studies) and one Finnish (Finn-Home study) cohorts taking HBP readings for 7 days	Morning	-	≥2 in Ohasama and Tsurugaya studies; 10 in Finn-Home study	-	Mean of all morning readings	Agreement between HBP and OBP in BP classification is optimal using ≥7 days of morning BP measurements.
Ohasama study ¹⁶	To investigate the optimal number of HBP measurements in association with stroke risk in 1491 Japanese Adults having 14–28 days of HBP measurements	Evening	1	-	-	Mean of all morning HBP readings	The predictive ability of HBP for stroke risk increased with more HBP readings, which should be derived from at least 3-day but preferably ≥14-day measurements.
HBP estimation based on morning and evening readings							
Finn-Home study ¹²	To explore optimal schedule for assessment of HBP variability in 1706 Finnish adults measuring HBP for 7 days	Morning and evening	2	2	10	Means of (1) all remaining morning readings, and (2) all remaining (morning and evening) HBP readings	HBP variability derived from ≥3-day systolic morning HBP was significantly associated with future CV events.

(Continues)

TABLE 2 (Continued)

HBP measurement protocol							
Study	Study objective	Each day			Rest time before HBP measurement (minute)	Estimation	Study results
		Morning	Evening	Measurements per occasion			
SMART study ³⁹	To determine number of HBP measurements for accurate BP estimates in 1710 French hypertensive patients measuring HBP for 4 days	8 a.m.	8 p.m.	3	-	V	Mean of all remaining measurements ≥6 HBP readings is needed to improve measurement precision.
Stergiou GS and colleagues ¹³	To determine minimum number of HBP for reliable BP estimate in 189 Greek hypertensive patients having HBP measured in 3 work days for 2 weeks	7 a.m. - 10 a.m.	6 p.m. - 9 p.m.	2	1	V	Mean of all remaining measurements ≥3 days of HBP measurements is needed to provide reliable HBP estimates.
J-HOP study ⁴	To determine the optimal schedule for HBP monitoring in prognostic risk of stroke and CAD in 4310 Japanese adults measuring HBP for 14 days	V (within 1 h after awakening, before breakfast, before taking antihypertensives)	V (before going to bed)	3	1/4	V	Mean of all remaining measurements Both morning and evening systolic HBP were independent predictors for stroke, rather than CAD.
IDH study ¹⁴	To determine number of measurements needed for HBP estimates in a community cohort of 316 American adults undertaking 21-day HBP measurements	V (immediately after awakening)	V	2	1	-	Mean of all measurements over the first 2 weeks Using the average of morning and evening readings, 3 days of HBP are needed to reliably diagnose hypertension

Abbreviations: BP, blood pressure; CAD, coronary artery disease; CV, cardiovascular; Finn-Home, Finnish home BP monitoring; HBP, home blood pressure; IDH: Improving the Detection of Hypertension; IDHOCO, International Database of HOme blood pressure in relation to Cardiovascular Outcome; J-HOP: Japan Morning Surge-Home Blood Pressure; NA, not available; OBP, office blood pressure; SMART: Self-Measurement for the Assessment of the Response to Trandolapril.
 -: indicated "not available" or "not recommended."

TABLE 3 Details of the HBP protocol recommended by different guidelines for the diagnosis and management of hypertension, ranked by year of publication

Guidelines & consensus (year of publication)	HBP protocol				Estimation				HBP threshold for high blood pressure	Long-term follow-up				
	Timing	Schedule	Time interval between repeated measurements (minute)	Rest time before HBP measurement (minute)	Minimal requirement	First day discarded	HBP estimate	HBP estimate						
ACC/AHA guideline (2018) ⁴⁰	-	V (Weekly, 2 weeks after regimen change)	7 days	V (before medication)	Morning V (before medication)	Evening V (before dinner)	No. of measurements on each occasion ≥ 2	1	≥ 5	≥ 2 measurement occasions	-	Mean of all measurements	130/80	-
ESC guideline (2018) ⁴¹	-	V	6-7 days	V	V	V	2	1-2	3-5	≥ 3 days	-	Mean of all measurements	135/85	-
Chinese guideline (2019) ⁴²	-	V	7 days	V (before medication and breakfast)	V (before medication)	V (before dinner)	2-3	1-2	≥ 5	≥ 6 days	V	Mean of all remaining measurements	135/85	1-2 days per week (once in the morning, once in the evening)
Korean guideline (2019) ⁴³	-	-	7 days	V (within 1 h after awakening, prior to medication and breakfast)	V (within 1 h after awakening, prior to medication and breakfast)	V (before going to bed)	1-3	NA	1-2	≥ 7 days for hypertension diagnosis; $\geq 5-7$ days before clinic visit	V	Mean of all remaining measurements	135/85	-
NICE guideline (2019) ⁴⁴	-	-	7 days	V	V	V	2	1	-	≥ 3 days	V	Mean of all remaining measurements	135/85	-
JSH guideline (2019) ²¹	-	V	7 days	V (within 1 h after awakening, prior to medication and breakfast)	V (before going to bed)	V (before going to bed)	2	NA	1-2	≥ 5 days	-	Mean of all measurements, and separate means of morning & evening readings	135/85	-

(Continues)

TABLE 3 (Continued)

Guidelines & consensus (year of publication)	HBP protocol		Schedule		Estimation					HBP threshold for high blood pressure	Long-term follow-up			
	Timing	Assessment of treatment	Before each visit	Duration	Morning	Evening	No. of measurements on each occasion	Time interval between repeated measurements (minute)	Rest time before HBP measurement (minute)			Minimal requirement	First day discarded	HBP estimate
Indonesian guideline (2019) ⁴⁵	-	V	-	≥3 days (within 1 h after awakening, medication, before breakfast)	V (within 1 h after awakening, before medication, before breakfast)	V (before going to bed)	2-3	1	-	≥3 days	V	Mean of all remaining measurements	135/85-	-
Canada guideline (2020) ⁴⁶	-	-	-	7 days	V (before breakfast and medication)	V (2 h after dinner, before medication)	2	NA	5	-	V	Mean of all remaining measurements	135/85	-
ISH guideline (2020) ⁴⁷	-	V	-	3-7 days	V (before medication)	V	2	1	5	-	V	Mean of all remaining measurements	135/85	1-2 measurements per week or per month
Taiwan guideline (2022) ⁴⁸	V	V	V	7 days (within 1 h after awakening, before medication and breakfast)	V (within 1 h before bedtime)	≥2 (≥ε3 in presence of atrial fibrillation)	2	1	≥5	≥4 days	V	Separate means of the remaining morning & evening readings	130/80	7-day ("722") cycle every 2 weeks to 3 months based on hypertension control status

Abbreviations: ACC, American College of Cardiology; AHA, American Heart Association; ESC, European Society of Cardiology; ESH, European Society of Hypertension; HBP, home blood pressure; HBPM, home blood pressure monitoring; HOPE Asia, Outcome Prevention and Evidence in Asia; ISH, International Society of Hypertension; JSH, Japanese Society of Hypertension; NICE, National Institute for Health and Care Excellence. -: indicated 'not available' or 'not recommended'.

TABLE 4 Details of the HBP protocol recommended by different guidelines and consensus for HBP monitoring, ranked by year of publication

Guidelines & consensus (year of publication)	HBP protocol		Schedule		Time interval		Estimation		HBP threshold for high blood pressure	Long-term follow-up					
	Timing	Confirmation of hypertension diagnosis	Assessment of treatment	Before each visit	Duration	Morning	Evening	No. of measurements on each occasion			Time between repeated measurements (minute)	Rest time before HBP measurement (minute)	Minimal requirement	First day discarded	HBP estimate
ESH guideline (2010) ⁴⁹	V	V	V	V	7 days	V (before medication)	V (before dinner)	2	1-2	≥5	≥3 days	V	Mean of all remaining measurements	135/85	1-2 measurements per week
JSH guideline (2012) ⁵⁰	V	-	V	-	2 to 4 weeks	V (within 1 h after awakening, prior to medication and breakfast)	V (before going to bed)	1-3	1-2	1-2	≥5 days	-	Mean of all measurements	135/85	≥3 days/week if BP is under control; ≥5 days/week for drug titration
HOPE Asia Network consensus (2018) ⁵	V	-	V	-	7 days	V (within 1 h after awakening, prior to medication and breakfast)	V (before going to bed)	≥2	1	2	≥3 days of both morning and evening measurements	-	Mean of all measurements and separate means of morning & evening readings	135/85	-
Chinese guideline (2020) ⁵¹	V	-	V	-	5-7 days	V (before breakfast and medication)	V (after dinner, before going to bed)	2-3	1	5	-	-	Mean of all measurements	135/85	≥1 day per week
Taiwan HBP consensus (2020) ¹⁹	V	V	V	V	7 days	V (within 1 h after awakening, prior to medication and breakfast)	V (within 1 h before bedtime)	≥2 (≥3 if atrial fibrillation)	1	5	≥4 days	V	Separate means of the remaining morning & evening readings	135/85	7-day ("722") cycle every 2 weeks to 3 months based on hypertension control status, or ≥€€1 occasion (with two measurements) per week
AHA & AMA joint statement (2020) ⁵²	V	-	V	-	7 days (8 days, if V first day is discarded)	V	V	2	1	5	≥3 days (≥€4 days if V first day is discarded)	V	Mean of all remaining measurements	130/80	1-3 days per week
ESH practice guideline (2021) ⁵³	V	-	V	-	7 days	V (before breakfast and medication)	V (before medication and dinner)	2	1	3-5	≥3 days	V	Mean of all remaining measurements	135/85	1-2 occasions (with two measurements per occasion) per week or per month

Abbreviations: ACC, American College of Cardiology; AHA, American Heart Association; AMA, American Medical Association; ESC, European Society of Cardiology; ESH, European Society of Hypertension; HBP, home blood pressure; HBPM, home blood pressure monitoring; HOPE Asia, Outcome Prevention and Evidence in Asia; ISH, International Society of Hypertension; JSH, Japanese Society of Hypertension; NICE, National Institute for Health and Care Excellence. -: indicated "not available" or "not recommended."

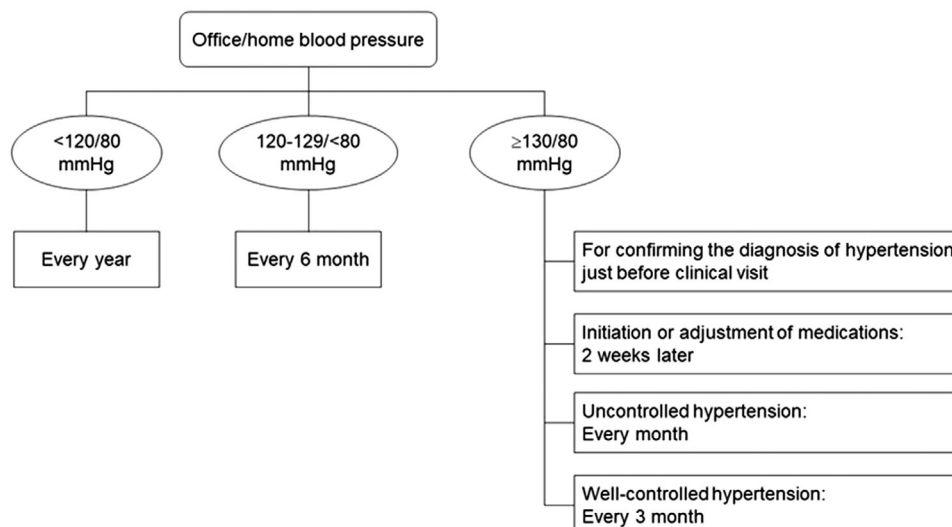


FIGURE 1 Frequency of follow-up of the “722” protocol for standardized home blood pressure monitoring according to different clinical scenarios

justified. Along with well-designed patient training and education programs, together with experienced healthcare coworkers and consultants, HBP measurement based on the “722” protocol can serve as the foundation for standardized HBP monitoring.

ACKNOWLEDGEMENTS

None.

CONFLICT OF INTEREST

YCC has received unrestricted educational grants from Viatrix and Omron and from Medtronic for activities of the Malaysian Society for World Action on Salt, Sugar and Health (MyWASSH); and also has received speaker honoraria from Medtronic, Astra-Zeneca, Omron and Xepa-Sol. KK reports research grant and consulting fees from A&D, Omron Healthcare, Fukuda Denshi; honoraria from Omron Healthcare; Participation in Advisory board of Fukuda Denshi, outside the submitted work.

AUTHOR CONTRIBUTIONS

Hung-Ju Lin wrote the manuscript. Heng-Yu Pan, Chen-Huan Chen, Hao-Min Cheng, Yook-Chin Chia, Guru Prasad Sogunuru, Jam Chin Tay, Yuda Turana, Narsingh Verma, Kazuomi Kario, and Tzung-Dau Wang reviewed and edited the manuscript. T.D.W. is the guarantor responsible for the integrity of this work.

REFERENCES

- Kario K. The HOPE Asia Network activity for “zero” cardiovascular events in Asia: overview 2020. *J Clin Hypertens (Greenwich)*. 2020; 22: 321-330.
- Niiranen TJ, Hänninen MR, Johansson J, Reunanen A, Jula AM. Home-measured blood pressure is a stronger predictor of cardiovascular risk than office blood pressure: the Finn-Home study. *Hypertension*. 2010; 55: 1346-1351.
- Bobrie G, Chatellier G, Genes N, et al. Cardiovascular prognosis of “masked hypertension” detected by blood pressure self-measurement in elderly treated hypertensive patients. *JAMA*. 2004; 291: 1342-1349.
- Hoshida S, Yano Y, Haimoto H, et al. Morning and evening home blood pressure and risks of incident stroke and coronary artery disease in the Japanese general practice population: the Japan morning surge-home blood pressure study. *Hypertension*. 2016; 68: 54-61.
- Park S, Buranakitjaroen P, Chen C-H, et al. Expert panel consensus recommendations for home blood pressure monitoring in Asia: the Hope Asia Network. *J Hum Hypertens*. 2018; 32: 249-258.
- McManus RJ, Mant J, Franssen M, et al. Efficacy of self-monitored blood pressure, with or without telemonitoring, for titration of antihypertensive medication (TASMINH4): an unmasked randomised controlled trial. *Lancet*. 2018; 391: 949-959.
- Sega R, Facchetti R, Bombelli M, et al. Prognostic value of ambulatory and home blood pressures compared with office blood pressure in the general population: follow-up results from the Pressioni Arteriose Monitorate e Loro Associazioni (PAMELA) study. *Circulation*. 2005; 111: 1777-1783.
- Asayama K, Ohkubo T, Metoki H, et al. Cardiovascular outcomes in the first trial of antihypertensive therapy guided by self-measured home blood pressure. *Hypertens Res*. 2012; 35: 1102-1110.
- Ohkubo T, Imai Y, Tsuji I, et al. Home blood pressure measurement has a stronger predictive power for mortality than does screening blood pressure measurement: a population-based observation in Ohasama, Japan. *J Hypertens*. 1998; 16: 971-975.
- Lin HJ, Pan HY, Chen WJ, Wang TD. Variation in blood pressure classification using 7 blood pressure estimation protocols among adults in Taiwan. *JAMA Netw Open*. 2020; 3: e2024311.
- Stergiou GS, Baibas NM, Kaloogeropoulos PG. Cardiovascular risk prediction based on home blood pressure measurement: the Didima study. *J Hypertens*. 2007; 25: 1590-1596.
- Juhanoja EP, Johansson JK, Puukka PJ, Jula AM, Niiranen TJ. Optimal schedule for assessing home BP variability: the Finn-home study. *Am J Hypertens*. 2018; 31: 715-725.
- Stergiou GS, Skeva II, Zourbaki AS, Mountokalakis TD. Self-monitoring of blood pressure at home: how many measurements are needed?. *J Hypertens*. 1998; 16: 725-731.
- Bello NA, Schwartz JE, Kronish IM, et al. Number of measurements needed to obtain a reliable estimate of home blood pressure: results

- from the improving the detection of hypertension study. *J Am Heart Assoc.* 2018; 7: e008658.
15. Niiranen TJ, Asayama K, Thijs L, et al. Optimal number of days for home blood pressure measurement. *Am J Hypertens.* 2014; 28: 595-603.
 16. Ohkubo T, Asayama K, Kikuya M, et al. How many times should blood pressure be measured at home for better prediction of stroke risk? Ten-year follow-up results from the Ohasama study. *J Hypertens.* 2004; 22: 1099-1104.
 17. Stergiou GS, Kollias A, Destounis A, Tzamouranis D. Automated blood pressure measurement in atrial fibrillation: a systematic review and meta-analysis. *J Hypertens.* 2012; 30: 2074-2082.
 18. Halfon M, Wuerzner G, Marques-Vidal P, et al. Use of oscillometric devices in atrial fibrillation: a comparison of three devices and invasive blood pressure measurement. *Blood Press.* 2018; 27: 48-55.
 19. Lin HJ, Wang TD, Yu-Chih Chen M, et al. 2020 consensus statement of the Taiwan hypertension society and the Taiwan society of cardiology on home blood pressure monitoring for the management of arterial hypertension. *Acta Cardiol Sin.* 2020; 36: 537-561.
 20. Sogunuru GP, Kario K, Shin J, et al. Morning surge in blood pressure and blood pressure variability in Asia: evidence and statement from the HOPE Asia Network. *J Clin Hypertens (Greenwich).* 2019; 21: 324-334.
 21. Umemura S, Arima H, Arima S, et al. The Japanese society of hypertension guidelines for the management of hypertension (JSH 2019). *Hypertens Res.* 2019; 42: 1235-1481.
 22. Kallioinen N, Hill A, Horswill MS, Ward HE, Watson MO. Sources of inaccuracy in the measurement of adult patients' resting blood pressure in clinical settings: a systematic review. *J Hypertens.* 2017; 35: 421-441.
 23. Mahe G, Comets E, Nouni A, et al. A minimal resting time of 25 min is needed before measuring stabilized blood pressure in subjects addressed for vascular investigations. *Sci Rep.* 2017; 7: 12893.
 24. Quer G, Nikzad N, Chieh A, et al. Home monitoring of blood pressure: short-term changes during serial measurements for 56398 subjects. *IEEE J Biomed Health Inform.* 2018; 22: 1691-1698.
 25. Brady TM, Charleston J, Ishigami J, Miller ER, Matsushita K, Appel LJ. Effects of different rest period durations prior to blood pressure measurement: the best rest trial. *Hypertension.* 2021; 78: 1511-1519.
 26. Tobe SW, Dubrofsky L, Nasser DI, Rajasingham R, Myers MG. Randomized controlled trial comparing automated office blood pressure readings after zero or five minutes of rest. *Hypertension.* 2021; 78: 353-359.
 27. Uchida S, Kikuya M, Asayama K, et al. Predictive power of home blood pressure in the evening compared with home blood pressure in the morning and office blood pressure before treatment and in the on-treatment follow-up period: a post hoc analysis of the HOMED-BP study. *Hypertens Res.* 2022; 45: 722-729.
 28. McManus RJ, Mant J, Bray EP, et al. Telemonitoring and self-management in the control of hypertension (TASMINH2): a randomised controlled trial. *Lancet.* 2010; 376: 163-172.
 29. McManus RJ, Mant J, Haque MS, et al. Effect of self-monitoring and medication self-titration on systolic blood pressure in hypertensive patients at high risk of cardiovascular disease: the TASMIN-SR randomized clinical trial. *JAMA.* 2014; 312: 799-808.
 30. McManus RJ, Little P, Stuart B, et al. Home and Online Management and Evaluation of Blood Pressure (HOME BP) using a digital intervention in poorly controlled hypertension: randomised controlled trial. *BMJ.* 2021; 372: m4858.
 31. Asayama K, Ohkubo T, Kikuya M, et al. Prediction of stroke by home "morning" versus "evening" blood pressure values: the Ohasama study. *Hypertension.* 2006; 48: 737-743.
 32. Kario K, Saito I, Kushihiro T, et al. Home blood pressure and cardiovascular outcomes in patients during antihypertensive therapy: primary results of HONEST, a large-scale prospective, real-world observational study. *Hypertension.* 2014; 64: 989-996.
 33. Okumiya K, Matsubayashi K, Wada T, et al. A U-shaped association between home systolic blood pressure and four-year mortality in community-dwelling older men. *J Am Geriatr Soc.* 1999; 47: 1415-1421.
 34. Niiranen TJ, Mäki J, Puukka P, Karanko H, Jula AM. Office, home, and ambulatory blood pressures as predictors of cardiovascular risk. *Hypertension.* 2014; 64: 281-286.
 35. Staessen JA, Den Hond E, Celis H, et al. Antihypertensive treatment based on blood pressure measurement at home or in the physician's office: a randomized controlled trial. *JAMA.* 2004; 291: 955-964.
 36. Verberk WJ, Kroon AA, Lenders JW, et al. Self-measurement of blood pressure at home reduces the need for antihypertensive drugs: a randomized, controlled trial. *Hypertension.* 2007; 50: 1019-1025.
 37. Obara T, Ohkubo T, Satoh M, Mano N, Imai Y. Home and office blood pressure control among treated hypertensive patients in Japan: findings from the Japan home versus office blood pressure measurement evaluation (J-HOME) study. *Pharmaceuticals (Basel).* 2010; 3: 419-432.
 38. Shimbo D, Pickering TG, Spruill TM, Abraham D, Schwartz JE, Gerin W. Relative utility of home, ambulatory, and office blood pressures in the prediction of end-organ damage. *Am J Hypertens.* 2007; 20: 476-482.
 39. Chatellier G, Dutrey-Dupagne C, Vaur L, et al. Home self blood pressure measurement in general practice. The SMART study. Self-measurement for the Assessment of the Response to Trandolapril. *Am J Hypertens.* 1996; 9: 644-652.
 40. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APHA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Hypertension.* 2018; 71: e13-e115.
 41. Williams B, Mancia G, Spiering W, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J.* 2018; 39: 3021-3104.
 42. Joint Committee for Guideline R. 2018 Chinese guidelines for prevention and treatment of hypertension-a report of the revision committee of chinese guidelines for prevention and treatment of hypertension. *J Geriatr Cardiol.* 2019; 16: 182-241.
 43. Lee HY, Shin J, Kim GH, et al. 2018 Korean Society of Hypertension Guidelines for the management of hypertension: part II-diagnosis and treatment of hypertension. *Clin Hypertens.* 2019; 25: 20.
 44. National Institute for Health and Care Excellence. Hypertension in adults: diagnosis and management. NICE Guideline. Accessed November, 2019. <https://www.nice.org.uk/guidance/ng136>
 45. Turana Y, Widyantoro B, Pratikto RS, Guideline of Home Blood Pressure measurement. Indonesian Society of Hypertension; 2019. http://faber.inash.or.id/upload/pdf/article_Update_konsensus_201939.pdf [in Bahasa]
 46. Rabi DM, McBrien KA, Sapir-Pichhadze R, et al. Hypertension Canada's 2020 comprehensive guidelines for the prevention, diagnosis, risk assessment, and treatment of hypertension in adults and children. *Can J Cardiol.* 2020; 36: 596-624.
 47. Unger T, Borghi C, Charchar F, et al. 2020 International Society of Hypertension global hypertension practice guidelines. *J Hypertens.* 2020; 38: 982-1004.
 48. Wang TD, Chiang CE, Chao TH. 2022 guidelines of the Taiwan Society of Cardiology and the Taiwan Hypertension Society for the management of hypertension. *Acta Cardiol Sin.* 2022; 38: 225-325.
 49. Parati G, Stergiou GS, Asmar R, et al. European Society of Hypertension practice guidelines for home blood pressure monitoring. *J Hum Hypertens.* 2010; 24: 779-785.
 50. Imai Y, Kario K, Shimada K, et al. The Japanese Society of Hypertension Guidelines for Self-monitoring of Blood Pressure at Home (Second Edition). *Hypertens Res.* 2012; 35: 777-795.
 51. Wang J-G, Bu P-L, Chen L-Y, et al. 2019 Chinese Hypertension League guidelines on home blood pressure monitoring. *J Clin Hypertens (Greenwich).* 2020; 22: 378-383.

52. Shimbo D, Artinian NT, Basile JN, et al. Self-measured blood pressure monitoring at home: a joint policy statement from the American Heart Association and American Medical Association. *Circulation*. 2020;142:e42-e63.
53. Stergiou GS, Palatini P, Parati G, et al. 2021 European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement. *J Hypertens*. 2021; 39: 1293-1302.

How to cite this article: Lin H-J, Pan H-Y, Chen C-H, et al. Standardized home blood pressure monitoring: Rationale behind the 722 protocol. *J Clin Hypertens*. 2022;24:1161-1173. <https://doi.org/10.1111/jch.14549>