Comparison of outcomes for routine versus American Heart Association-recommended technique for blood pressure measurement (CORRECT BP): a randomised cohort study

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Summary

Background Optimal clinical care, diagnosis and treatment requires accurate blood pressure (BP) values. The primary objective was to compare BP readings taken while adhering to American Heart Association (AHA) guidelines to those typical of routine clinical care. Specifically studied: the combined effect of feet flat on the floor, back supported, and arm supported with cuff at heart level, while adhering to other guideline recommendations.

Methods In this prospective, randomised, three-group cohort study, a modified cross-over design was applied in a primary care outpatient office setting in Columbus (OH, USA). Eligible participants were adults (aged ≥18 years) with an arm circumference of ≥18 cm and ≤42 cm who did not have a renal dialysis shunt or a previous or current diagnosis of atrial fibrillation. 150 recruited volunteers meeting the inclusion criteria were randomly randomised into the three groups. Group methodologies were BP readings taken on a fixed-height exam table followed by readings taken in an exam chair with adjustable positioning options (Group A), readings taken in the reverse order, chair then table (Group B), and both sets of readings in the exam chair (Group C). A rest period occurred before each set of readings. Group C was included for the purpose of obtaining an independent estimate of the order effect. The order in which the two types of readings (table vs chair) were taken was randomised. The primary outcome was the difference between the mean of three BP readings taken on the table and the mean of three readings taken in the chair.

Findings Between September and October, 2022, 150 participants were enrolled in the study; all 150 of whom completed testing: 48 in Group A, 49 in Group B, 53 in Group C. The mean systolic/diastolic BP (SBP/DBP) of readings taken on the table (Group A first readings, Group B second readings) were 7.0/4.5 mmHg higher than those taken in the chair (Group A second readings, Group B first readings); both statistically significant, $p < 0.0001$. These findings show that AHA-recommended positioning—feet flat on the floor, back supported, arm supported with the BP cuff at heart level—results in substantially lower BP values than improper positioning. The mean SBP/DBP of the first set of readings taken on the chair were 1.6/0.6 mmHg higher than for the second set of readings (Group C, included to estimate order effect).

Interpretation The observed benefit of proper positioning is sufficient to change the BP classification of several million patients from having hypertension to not having hypertension and therefore avoiding medication and/or intense follow-up.

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Research in context

Evidence before this study

The American Heart Association (AHA) has published a series of scientific statements describing in detail the proper protocol to obtain accurate blood pressure (BP) readings. The key points to ensuring accurate BP measurement relate to 1) selecting the proper size cuff; 2) no clothing under the cuff; 3) no talking during BP assessment; 4) legs uncrossed with feet flat on the floor; 5) back supported; 6) arm supported with cuff at heart level; and 7) patient seated for at least 3–5 min prior to the first reading. A systematic review and other studies assessing proper technique when taking BP measurements revealed serious deficiencies in adherence to the AHA recommendations. What is not currently known is the cumulative effect of poor positioning that occurs when BP is taken with the patient sitting on a typical clinical exam room table.

Added value of this study

The findings of our prospective, randomised cohort study show that AHA-recommended positioning—feet flat on the floor, back supported, arm supported with the BP cuff at heart level—results in substantially lower BP values than improper positioning. Pooled systolic/diastolic BP readings taken with incorrect positioning (exam table) were markedly higher by 7.0/4.5 mmHg (both $p < 0.0001$).

Implications of all the available evidence

AHA-recommended positioning is critical for accurate BP measurements. Considering the new findings from this study, the observed benefit of proper positioning is sufficient to change the BP classification of several million patients from hypertensive to normal, avoiding medication and/or intense follow-up.

Introduction

Accurate measurement of blood pressure (BP) is essential for both patient risk stratification and guiding the management of hypertension (HTN).[1] Inaccurate BP measurement can lead to either a missed diagnosis or misdiagnosis, both of which can cause harm to patients by either not appropriately treating patients with hypertension or medicating patients who are not hypertensive, respectively. As such, it is critical to develop and utilise equipment, procedures, and sufficient training to maximise the point of care accuracy of BP measurement and thus promote appropriate decision making for therapeutic BP management and ultimately optimised HTN control.

HTN is the leading risk factor for heart disease worldwide.[1] Suboptimal control of HTN can lead to increased risk of kidney disease, peripheral artery disease, and vascular dementia. To improve patient outcomes in general and for those with numerous chronic conditions in particular, especially cardiovascular disease, the BP values guiding therapeutic management must be accurate.[1] The American Heart Association (AHA) has published a series of scientific statements describing in detail the proper protocol to obtain accurate BP readings.[2–5] The key points to ensuring accurate BP measurement relate to 1) selecting the proper size cuff; 2) no clothing under the cuff; 3) no talking during BP assessment; 4) legs uncrossed with feet flat on the floor; 5) back supported; 6) arm supported with cuff at heart level; and 7) patient seated for at least 3–5 min prior to the first reading.[1] However, in routine care there are many barriers to successfully implementing these guidelines.[5]

A systematic review assessing how often proper technique is utilised when taking BP measurements revealed serious deficiencies in adherence to the AHA recommendations.[6] Another study found that medical students, when explicitly challenged, were unable to adhere to AHA recommendations.[7] In one of the first studies to examine the effect of improper positioning on BP, Cushman et al. found that diastolic blood pressure (DBP) was 6.5 mmHg higher when taken on an exam table without back support vs in a chair with back support, but found no significant difference in systolic blood pressure (SBP) between the two conditions.[8] Kallioinen et al. also summarised data on the estimated effect on BP measurement of failing to adhere to individual AHA recommendations.[6] What is not currently known is the cumulative effect of poor positioning that occurs when BP is taken with the patient sitting on a typical clinical exam room table.

To address this, we designed the Comparison of Outcomes for Routine versus American Heart Association-Recommended Technique for Blood Pressure Measurement (CORRECT BP) Study. In this study, we compared BP readings obtained while strictly adhering to published AHA guidelines with BP readings obtained using methods currently practiced in many clinical settings.[9,10] In particular, we evaluated the effect on BP of failing to ensure that feet are properly positioned flat on the floor, the back is supported, and the arm is supported with the cuff at heart level.

Methods

Study population

Participants were recruited in September and October, 2022, from the patients and staff at an outpatient office setting of The Ohio State University Wexner Medical Center in Columbus (OH, USA). The study was

approved by The Ohio State University Institutional Review Board and each participant provided written informed consent (WCG IRB Protocol #20223202 OSU IRB 2022W0060). The numbers of recruited and enrolled participants and those randomised into the three study groups are shown in Fig. 1. Participants in the study met the following criteria for enrollment.

Inclusion criteria

Inclusion criteria were adults aged at least 18 years who were willing and able to understand and follow instructions in English and to provide a signed informed consent form (ICF), who also had an arm circumference of ≥18 cm and ≤42 cm and who had no presence of previous or current known diagnosis of atrial fibrillation as reported by the individual or determined by medically trained site personnel during screening and no presence of a renal dialysis shunt.

Exclusion criteria

Exclusion criteria were individuals who reported a current pregnancy or refused to participate/sign the study's ICF and individuals with a febrile illness (temperature >100.4° Fahrenheit).

Study design

This was a three-group randomised clinical study with a cross-over design. Group A had three BP readings taken while seated on a fixed-height exam table followed by three readings taken in a position-adjustable exam chair; and Group B had three BP readings taken in the chair followed by three readings taken on the table. The order in which the two types of readings were taken was randomised. Group C had three BP readings taken in the exam chair followed by another three readings taken in the chair and was included for the purpose of obtaining an independent estimate of the order effect. When either the difference between the lowest and highest of the three SBP readings or the difference between the lowest and highest of the three DBP readings exceeded 10 mmHg, a fourth BP reading was taken 1 min later. This was done to allow any statistical outliers detected during the analysis of the data to be replaced.

Randomisation

Prior to enrollment of the first participant, an allocation table was created for randomly assigning consecutively enrolled eligible participants to one of the three

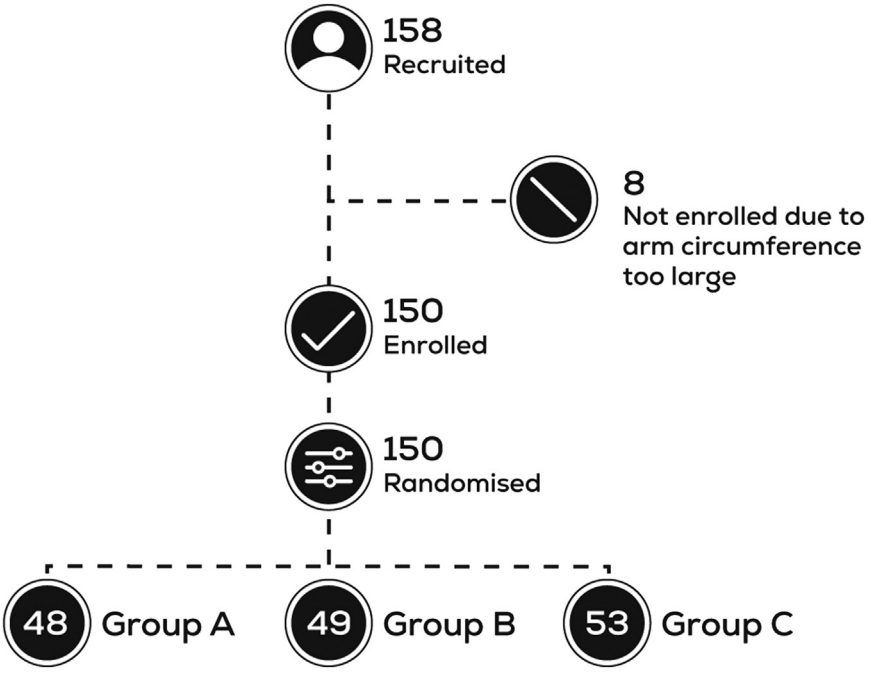

Fig. 1: Numbers of study participants recruited and enrolled in the study and randomised into the three study groups.

described groups. The allocation table was generated in SAS (Version 9.4, SAS Institute, Cary, NC, USA) and incorporated permuted block randomisation with block sizes of either 9 or 12 to ensure that the groups would be of nearly equal size.

Protocol

To ensure proper participant positioning following AHA recommendations, the Midmark 626 Barrier-Free® Examination Chair was used (Model 626-001; Midmark Corporation, Versailles, Ohio, USA). The barrier-free low chair height allowed a participant to place their feet flat on the floor, and powered movement of the back section helped ensure the participant's back was supported. We employed the Midmark Patient Support Rails + accessory for the chair to support the arm with the BP cuff at heart level.

To simulate routine clinical care positioning for BP measurement using a fixed-height exam table, the Midmark 625 Barrier-Free® Examination Table was used (Model 625-006; Midmark Corporation, Versailles, Ohio, USA) while adhering to as many of the AHA recommendations as the table allowed. When the participants were seated on this exam table with the back rest down and the height set to the same height as non-powered exam tables, neither feet nor back were supported, and the tested arm was at the participant's side, unsupported, with the cuff not at heart level.

The examination room for the testing contained both the chair and table to facilitate movement from one to the other. The research staff, consisting of only two office personnel, initially measured the participant's mid-arm circumference and selected the proper cuff size to be used. Current best-practice recommendations from the AHA[1] include the use of automated BP capture to reduce the inaccuracies and inconsistencies that often occur when performing an auscultation method. To obtain the BP readings for this study, the Midmark IQvitals® Zone™ automated oscillometric BP device was used (Model 1-200-0360; Midmark Corporation, Buffalo Grove, Illinois, USA). This device is FDA cleared and the deflation algorithm type used in this study is validated to the requirements of the ANSI/AAMI/ISO 81060-2 Standard and the British Hypertension Society (BHS) Protocol.[11] (preprint) The protocol followed in this study for each of the three study groups is detailed in Table 1. The complete study protocol is also included in the Supplementary Materials.

Blinding

Although the research staff performing the BP measurements could not be blinded to group assignment, they were unable to influence the group to which a participant was assigned. Furthermore, the use of an automated oscillometric BP device minimised any influence the staff might have had on the BP measurements.

Statistical analyses

Preliminary analyses

The study's pre-specified analysis plan did not address the detection and treatment of potential outliers or the conditions under which a fourth BP reading, when available, should be used. However, prior to conducting the primary analysis, a plan was developed to use Mahalanobis distance (D_M)[12] as a metric to quantify the variability among the three SBP readings and the variability among the three DBP readings and identify those sets of readings for which D_M was significantly greater than would be expected by chance (see Supplementary Materials for complete details). This approach identified sets of three readings that contained at least one outlier (SBP and/or DBP reading). Upon review of the three readings, the reading that was inconsistent with the other two was easily identified and this reading was replaced using the fourth BP reading. Of the 97 sets of readings taken on the table, ten (10.3%) contained an outlier that was replaced; of the 203 sets of readings taken in the chair, five (2.5%) contained an outlier that was replaced. For each outlier identified, there was a fourth reading available to replace it.

Missing data

There were no missing BP data.

Primary analysis (pre-specified)

A multilevel, linear mixed model was used to analyse the two sets of three SBP readings. The sole predictor was the Group × Set interaction (no intercept), resulting in estimates for each Group of the mean (and standard error) of the three SBP readings for each set. An unstructured 6 × 6 covariance matrix, separate for each Group, was specified. Seven contrasts were estimated, three of which are reported here (see Supplementary Material for complete details):

Contrasts 1–2. The mean of Set 2 minus the mean of Set 1 for Group A (table—chair) and Group B (chair—table), respectively.

Contrast 7. The pooled estimate of the mean BP when taken on the table minus the mean BP when taken in the Chair (equals contrast 2 minus contrast 1).

The pooled estimate of the difference in BP between readings taken on the table versus those taken in the chair, Contrast 7, is the primary outcome. The identical analyses were performed for DBP. Bland–Altman plots[13] of the mean BP taken on the exam table and mean BP taken in the chair were created (post-hoc).

Sensitivity analysis

The primary analysis was repeated (post-hoc) using the original data where none of the outlier readings were replaced with the fourth reading. We conducted another pre-specified analysis that ignored the first reading of each set of measurements, averaging the second and third readings, as is recommended in some

Group A	Group B	Group C
Participant's arm circumference measured over bare skin and appropriate size BP cuff applied		
Sit in the chair without optimising settings		
A single non-resting oscillometric BP reading taken		
Walk to and sit on the table	Optimise chair settings for feet, back, and arm requirements	Optimise chair settings for feet, back, and arm requirements
5-min rest period		
Take first set of three oscillometric readings, separated by 1 min[a]		
Walk to and sit in the chair; optimise settings for feet, back, and arm requirements	Walk to and sit on the table	Walk to the table and back; resume sitting in the chair
3-min rest period		
Take second set of three oscillometric readings, separated by 1 min[a]		
Remove cuff and discharge participant		

BP, blood pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure. [a]In the event that the difference between the lowest and highest of the three SBP readings or the difference between the lowest and highest of the three DBP readings exceeded 10 mmHg, a fourth BP reading was taken 1 min later.

Table 1: **Study protocol for the three participant groups.**

guidelines. Finally, since often in clinical practice only a single reading is taken, we conducted a post-hoc analysis comparing only the first reading of each set of measurements.

Statistical power

The statistical power analyses indicated that when pooling the results from Group A and Group B, with N = 50 participants per group, the power of a 2-tailed, $\alpha = 0.05$ test to detect a difference of $\geq$3.0 mmHg between the mean of three SBP readings taken on the table and the mean of three SBP readings taken in the chair would be $\geq$ 91.0%. When testing the difference within either Group A or Group B, with N = 50 participants, the power to detect a difference of $\geq$4.0 mmHg between the two means would be $\geq$ 87.5%. Based on these power calculations, we decided to enroll and randomise individuals until 150 participants (approximately 50 per group) had completed the protocol.

Role of the funding source

Midmark Corporation provided funding to The Ohio State University for the study, and contracted with CTI Clinical Trial and Consulting Services, Inc., to conduct the study. The Sponsor was not substantially involved with decisions related to the study design, nor with data collection, analysis, or interpretation of the data. Midmark personnel who are named in the Acknowledgments contributed to the written descriptions of the exam chair and exam table used during the study and provided other editorial support and reviews to the authors of the manuscript. They were not involved in decisions regarding submission of the manuscript for publication.

Results

As planned, 150 participants completed testing: 48 in Group A, 49 in Group B, 53 in Group C. No adverse events occurred. No participant had to be excluded for non-compliance with the protocol. Demographic and clinical characteristics of the sample are shown in Table 2.

Primary analysis

In the primary analysis of all 150 participants, after replacement of the outlier reading with the fourth reading in 15 of the 300 sets of BP readings, the mean of the three SBP/DBP readings taken on the exam table were, on average, 7.0/4.5 mmHg higher than the mean

Attribute	Group A table, chair (N = 48)	Group B chair, table (N = 49)	Group C chair, chair (N = 53)	All (N = 150)
Female[a], N (%)	35 (73%)	33 (67%)	35 (66%)	103 (69%)
Male[a], N (%)	13 (27%)	16 (33%)	18 (34%)	47 (31%)
Race, N (%)				
Asian	1 (2%)	1 (2%)	1 (2%)	3 (2%)
Black/African-American	20 (42%)	24 (49%)	30 (57%)	74 (49%)
White	26 (54%)	24 (49%)	22 (42%)	72 (48%)
Other	1 (2%)	0	0	1 (1%)
Age, years	55.2 (17.7)	50.1 (15.1)	50.6 (14.8)	51.9 (16.0)
Weight, pounds	197.4 (46.8)	217.8 (48.3)	198.5 (53.2)	204.4 (50.2)
Height, inches	66.1 (3.6)	67.2 (3.7)	67.2 (3.8)	66.8 (3.8)
BMI, kg/m^2	31.6 (6.3)	34.0 (7.5)	30.9 (7.8)	32.2 (7.3)
Upper arm circ, cm	34.7 (5.0)	36.1 (4.6)	34. 1 (4.2)	34.9 (4.6)
Non-resting SBP, mmHg	134.4 (18.5)	136.0 (23.2)	132.1 (20.6)	134.1 (20.8)
Non-resting DBP, mmHg	83.1 (10.4)	85.2 (12.4)	83.9 (9.4)	84.1 (10.7)
Medical history, N (%)				
Hypertension	23 (50%)	23 (49%)	19 (38%)	65 (45%)
Diabetes	0	1 (2%)	0	1 (1%)
None	23 (50%)	23 (49%)	31 (62%)	77 (54%)
(Missing)	2 (4%)	2 (4%)	3 (6%)	7 (5%)

Note: Mean (standard deviation) provided unless otherwise indicated. BMI, body mass index; Kg/m^2, kilogrammes per square metre; circ, circumference; cm, centimetres; SBP, systolic blood pressure; mmHg, millimetres of mercury; DBP, diastolic blood pressure; Table, fixed-height exam table; Chair, position-adjustable exam chair. [a]Self-reported, on the patients' clinic charts.

Table 2: **Participant demographic and clinical characteristics.**

of the three readings taken in the position-adjustable exam chair (see Table 3).

In addition to the effect of positioning (table vs chair), we had anticipated there would be an "order effect" such that the second set of readings would tend to be lower than the first set. As such, we expected the table minus chair difference in BP measurements to be greater in Group A (table followed by chair) than Group B (chair followed by table). Table 3 also presents the difference between the BP readings taken on the table versus those taken in the chair separately for Groups A and B. The difference between BPs taken on the table versus in the chair were substantial and statistically significant, regardless of the order in which the two modalities were assessed. The anticipated order effect is evident for DBP, but contrary to expectations, there was no order effect for SBP; contrast 4 in Supplementary Material eTable S3 shows the pooled estimate of the order effect. Bland–Altman plots of the mean BPs are provided in the Supplementary Material.

Sensitivity analysis

We repeated the preceding analysis without replacing the outlier BP with the fourth BP reading for those 15 sets of readings that contained an outlier (see Supplementary Material eTables). The results were similar. We also conducted an analysis where the first BP reading of each set was ignored and only the second and third readings were used to calculate the mean; again, the mean SBP/DBP of readings taken on the table were substantially higher than the means of readings taken in the chair (see Supplementary Material eTables). Lastly, an analysis comparing the first BP reading taken on the table versus in the chair yielded very similar results (see Supplementary Material eTables).

Group C

The inclusion of Group C (both first and second set of readings were taken in the chair) was included in the study design to obtain a "clean" estimate of the order effect when both sets of readings were taken as recommended. Contrary to our expectation, mean SBP and DBP were, respectively, 1.6 mmHg and 0.6 mmHg higher for the second set of readings (see contrast 3 in Supplementary Material eTable S3). This increase was entirely due to differences in the first of three readings in each set; in the sensitivity analysis that used only the second and third readings of each set, there was virtually no order effect in Group C (see contrast 3 in Supplementary Material eTable S5).

Outcome	Mean	Standard error	95% CI	p-value
Overall[a]				
Systolic BP, mmHg	6.97	0.71	5.58, 8.37	<0.0001
Diastolic BP, mmHg	4.47	0.39	3.70, 5.23	<0.0001
Group A (table, chair)				
Systolic BP, mmHg	7.04	0.94	5.18, 8.90	<0.0001
Diastolic BP, mmHg	5.63	0.61	4.43, 6.83	<0.0001
Group B (chair, table)				
Systolic BP, mmHg	6.91	1.05	4.83, 8.99	<0.0001
Diastolic BP, mmHg	3.31	0.48	2.36, 4.26	<0.0001

mmHg, millimetres of mercury; BP, blood pressure; Table, fixed-height exam table; Chair, position-adjustable exam chair; CI, confidence interval. [a]Pooled estimate based on Groups A and B.

Table 3: **Mean difference between blood pressure readings taken on the table versus those taken in the chair.**

Discussion

The primary analysis examined the difference in BP between those readings taken on the table versus those taken using proper positioning as recommend by the AHA in the chair (recommended practice). BP readings taken on the table were substantially higher (7.0/4.5 mmHg) than those taken in the chair with the difference being highly statistically significant ($p < 0.0001$) for both SBP and DBP. The difference was similar and statistically significant regardless of the order in which the two modalities were assessed. Our finding that BP measurements taken on the table were, on average, substantially higher than those taken in the chair is consistent with the findings by Kallioinen et al. regarding the effects of not having feet on the floor, back supported and BP cuff at heart level.[6]

Despite the impact of BP measurement on the treatment of most of the leading causes of death, its measurement is often viewed as a routine test performed by a nurse or medical assistant.[4] Unlike many other diagnostic procedures performed at the point of care, attention to proper methods, techniques, and protocols for properly measuring BP is often lacking or ignored. There is a general under-appreciation of the significant clinical impact proper technique has on the accuracy of this important vital sign. The current AHA guidelines, recommending therapeutic intervention at lower BP thresholds than prior clinical standards (130/80 mmHg instead of 140/90 mmHg),[14] have resulted in over 30 million additional patients in the United States being classified as having HTN.[15] In addition, in order to meet the lower target thresholds for SBP and DBP, those previously on a therapeutic regimen for HTN now require higher doses or additional pharmaceutical agents, which incurs added risk for adverse events related to medications.

Notwithstanding the critical importance of balancing the control of both hypertensive disease and potential adverse treatment effects through BP management, many of the recommendations related to proper positioning are often not employed during routine care.[1,6,9] In many office-based practices, the BP manometer (often aneroid) is kept next to a fixed-height exam table. In this common examination room setup, it is not possible to follow the protocol recommended by the

AHA, and in particular those aspects of the protocol pertaining to the positioning of feet, back, and arm. Other recommendations not related to positioning that are often ignored include a 5-min rest period between when the patient is positioned and the initiation of the first BP reading, as well as not talking during the BP acquisition process.[1] We designed and performed this study with the primary goal of comparing BP readings taken while the participant was in the recommended position sitting in a position-adjustable exam chair versus readings taken with the participant seated on a fixed-height exam table.

In a recent analysis of NHANES data, Sakhuja et al.[16] estimated that a systematic upward bias of only 5 mmHg SBP and 3.5 mmHg DBP would result in 23.6 million (95% CI: 19.5–27.6) additional adults in the United States meeting the American College of Cardiology (ACC) and AHA criteria for HTN even though their true BP was <130/80 mmHg. Among adults taking antihypertensive medication, they estimated that this same level of bias would result in 6.4 million (95% CI: 4.8–7.9 million) more adults incorrectly appearing to have uncontrolled HTN. In the present study, the upward bias due to taking BP readings on a fixed-height exam table was nearly 50% greater than that evaluated by Sakhuja et al.[16] This result demonstrates that when BPs are taken in the recommended position, the readings are lower and that simply following proper protocol could reduce the misdiagnosis of HTN for millions of patients, avoiding unnecessary medication or more intense follow-up. Healthcare costs in the United States are $131 billion per year higher for adults with hypertentsion when compared with the nonhypertensive population.[17] The proper assessment of BP is more than just clinically important, there are financial ramifications as well.

The results of this study demonstrate that following the AHA protocol (regarding positioning) for obtaining BP readings is critical for BP measurement, and failure to do so can seriously impede the accurate diagnosis and appropriate treatment of many conditions, especially HTN.

This study has several limitations including the reliance on a single outpatient clinical practice site for participant enrollment and the use of a single automated device to capture BP readings which may limit the generalisability of the results to other practice settings. Physicians at the site made decisions as to which of their patients and staff to refer for study screening, which may have influenced the participant selection process despite the adherence to clearly articulated inclusion and exclusion criteria. While these limitations might affect the external validity of the results, randomisation of enrolled participants to the three groups, use of an oscillometric device, and the resulting similarity of groups on demographic and clinical characteristics suggest that the internal validity of the results is high.

Advanced statistical modeling was one of several strengths of the study, in addition to the random assignment of participants to the groups and the predesigned collection of an additional BP measurement in the event of a potentially erroneous measurement; i.e., considering human factors, such as potential anxiety occurring with repeated BP measurements.

As demonstrated by our findings, the consequences of improperly measuring BP are notable. BP readings taken on a fixed-height exam table where proper AHA protocol cannot be achieved—including feet flat on the floor, back supported, and arm supported with the cuff at heart level—are significantly higher than BP readings taken with the proper technique. The common, yet easily avoidable, problem of failing to follow the entire AHA BP protocol can result in unnecessary healthcare expenditures and potentially serious adverse effects due to the unnecessary or over-treatment of tens of millions of patients.

Contributors

JES and RKW accessed and verified the underlying data reported in the manuscript.

BSA and JES contributed to the conceptualisation, formal analysis and data interpretation, investigation, methodology, and writing of the original draft and review and editing through the final draft. JES also contributed to the data validation and performed the statistical analyses. MS contributed to the data curation and access, formal analysis and data interpretation, investigation, methodology, project administration, data validation, and review and editing through the final draft. RKW contributed to the identification of site resources/personnel, conceptualisation, formal analysis and data interpretation, funding acquisition for the clinical site, investigation, methodology, project administration and supervision, data validation, and review and editing of the manuscript through the final draft.

Data sharing

The data that support the findings of this study are available from the corresponding author, Dr. Randell Wexler, upon reasonable request. The SAS code used to analise the data are available from Dr. Joseph Schwartz (joseph.schwartz@stonybrookmedicine.edu).

Declaration of interests

BSA: I received a consulting fee paid by Midmark for design of the study. I serve as convenor of the ISO Sphygmomanometer Committee and consultant to A+D Medical, Casana Care, Vital Labs, Omron Medical, and Bios Medical. JES: I had no formal relationship with Midmark Corporation, the manufacturer of the chair, table and automated BP device used in the study and sponsor of the study but did receive two honorarium payments from Midmark after the study was completed. MS: CTI Employed by them at that time of manuscript writing. I was assigned to the project. RKW: Midmark made payment to the Ohio State University Wexner Medical Center for the conduction of the study. I received no direct reimbursement. All other authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.eclinm.2023.102219.

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