Hypertension

Effects of Different Rest Period Durations Prior to Blood Pressure Measurement: The Best Rest Trial

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ABSTRACT: A rest period of 3 to 5 minutes before blood pressure (BP) measurement is recommended in hypertension guidelines but can be challenging to implement. We conducted a randomized trial to determine the effects of resting for <5 minutes on BP. In a cross-over design, 113 participants (mean age 55 years, 36% male, 75% Black) had 4 sets of triplicate BP measurements with the order of rest for the first 3 sets (0 minutes, 2 minutes, 5 minutes$_1$) randomized. The fourth set was always a second 5-minute rest period (5 minutes$_2$), from which we calculated the difference between 5 minutes$_1$ and 5 minutes$_2$ (5 minutes$_1$—5 minutes$_2$), a measure of intrinsic BP variability. To determine if there was no difference between BPs obtained after resting 0 minutes or 2 minutes versus 5 minutes$_1$, we tested whether 5 minutes$_1$—0 minutes or 5 minutes$_1$—2 minutes was within a prespecified noninferiority margin of ±2 mm Hg compared with 5 minutes$_1$—5 minutes$_2$. Overall, mean BP was similar across 5 minutes$_1$ (128/75), 5 minutes$_2$ (127/76), 2 minutes (127/74), and 0 minutes (127/74). Compared with the average absolute 5 minutes$_1$—5 minutes$_2$ difference (5.3/3.0 mm Hg), the absolute systolic BP difference of differences did not cross our noninferiority margin for 0 minutes rest (0.2 [95% CI, 0.8−1.2]) but did for 2 minutes rest (−1.7 [−2.8 to −0.6]). Among those with systolic BP <140, the absolute difference of differences for both 0 and 2 minutes did not cross the ±2 mm Hg margin; however, those with systolic BP ≥140 had differences that did exceed this threshold. Our findings suggest that shorter rest periods may be a reasonable alternative to 5 minutes for most individuals. Implementation could substantially improve the efficiency of hypertension screening programs.

Hypertension remains a global public health concern. Worldwide, 1.13 billion people have a diagnosis of hypertension,[1] the leading cause of cardiovascular disease morbidity and mortality. A major contributor to the burden of hypertension is the repeated finding that a large fraction of individuals are unaware of their diagnosis.[2] Hence, broad efforts to screen, identify, and diagnose this treatable risk factor are essential to improve hypertension control. Although research studies and quality improvement efforts have often focused on improving the quality of blood pressure (BP) measurement, the process of obtaining BP measurements also

needs to be time-efficient to facilitate population-based screening.

For decades, national and international hypertension guidelines have recommended that patients rest for 3 to 5 minutes before initiation of BP measurements, citing this step as one of the "key steps for proper blood pressure measurement."[3] This rest period is challenging to implement, particularly in resource-constrained settings, and is often not adhered to in clinical practice, even in economically developed countries.[4–6]

The effect of resting for less than the recommended 3 to 5 minutes on BP among patients with both normal and

Novelty and Significance

What Is New?
- Very few studies have rigorously tested the effect of resting for less than the guideline-recommended 3 to 5 minutes before automated blood pressure (BP) measurement, and most studies were not randomized trials.

What Is Relevant?
- Resting for 3 to 5 minutes before BP measurement is time consuming and challenging to implement, particularly in resource-constrained settings.
- Eliminating the routine need for antecedent rest before BP measurement could substantially increase the

number of people screened, diagnosed, and treated for hypertension worldwide.

Summary
In our trial, BP measurements obtained after shorter (2 minutes) and no (0 minutes) rest periods resulted in minimally different BP values than those obtained after 5 minutes of rest. Our findings suggest that shorter rest times, even no rest, may be reasonable for screening, with 5 minutes of rest only implemented when the average systolic BP is ≥140 mm Hg.

Nonstandard Abbreviations and Acronyms

ABPM	ambulatory blood pressure monitor
AOBP	automated office blood pressure
BP	blood pressure
DBP	diastolic blood pressure
SBP	systolic blood pressure

elevated BP has not been reported yet would be informative in assessing the risk of misclassifying a diagnosis of hypertension. Our principal objective was to determine the effect of no rest (0 minutes) or a shortened rest (2 minutes) period on BP when compared to BP values measured after 5 minutes of rest. Other objectives were to determine if triplicate BP measurements were more or less variable following different durations of initial rest time and to determine the total amount of time required for BP measurement after each rest period.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request. We conducted a randomized clinical trial utilizing a cross-over design to compare the effects of rest time on the average of triplicate BP readings when the rest period before BP measurements was 0 or 2 minutes versus 5 minutes (reference). A Johns Hopkins University School of Medicine institutional review board approved this study. All participants provided written informed consent.

Study Population

Participants were community-dwelling adults, ≥18 years of age, recruited to achieve a broad BP distribution, that is, roughly a third with normal BP, a third with elevated BP but without hypertension, and a third with hypertension. Exclusion criteria, mostly related to barriers to accurate BP measurement, were (1) rashes, casts, edema, paralysis, open sores or wounds, or arteriovenous shunts on both arms; (2) phlebotomy within last

week; (3) cognitive impairment; (4) pregnancy; (5) midarm circumference >50 cm. Recruitment strategies included direct mailings to prior study participants of the research team, mass mailings to residents within 25 miles of the research facility, community BP screening events followed by targeted recruitment of individuals with BP in range, and university-wide email solicitation for study volunteers.

Randomization and Design

Participants had a single study visit at 1 of 2 sites, the ProHealth Research Center or the Welch Center for Prevention, Epidemiology, and Clinical Research, both in Baltimore, Maryland. During this visit, each participant underwent 4 sets of triplicate BP measurements in the presence of trained research staff using a fully automated oscillometric BP device (Omron HEM-907XL, Kyoto, Japan). The device was programmed to initiate 3 measurements, 60 seconds apart, automatically after the assigned rest period. The average of the triplicate measurements was used as the BP reading for each rest period.

Participants were randomized to 1 of 6 groups, each with a different assigned order of the 3 rest times before initiation of BP measurements: no rest (0 minutes), 2 minutes of rest (2 minutes), or 5 minutes of rest (5 minutes). In addition to these 3 randomized rest periods, every participant underwent a fourth (and final) set of triplicate measurements after 5-minute rest. Two sets of BPs obtained after 5 minutes of rest allowed us to account for the inherent, intraindividual variability within BPs obtained after 5 minutes of rest. We expressed the first set of triplicate BPs after 5 minutes rest as 5 minutes$_1$ (reference) and the second set of BPs after 5 minutes rest as 5 minutes$_2$.

The protocol before each set of BP measurements was identical and was designed to simulate a typical experience during BP screening. Specifically, before each set of triplicate BP measurements, participants were asked to walk at their own pace for 2 minutes (to simulate walking to the clinic), sit in a nonquiet, public space for 10 minutes where participants could talk, read, use smartphones as they would in a clinic waiting room, and then walk a uniform distance to the BP measurement station (≈20 m). Once seated, the BP cuff was placed, and participants rested their assigned time (no rest for 0 minutes) in a quiet, private room, without talking and without smartphone use. Once the 3 BPs were obtained, the BP cuff was removed,

and the participant repeated the steps above until they had a total of 4 sets of triplicate BP measurements.

BP Measurement

For uniformity, each BP measurement was taken in the right arm with the midpoint of the cuff positioned at heart level; the left arm was utilized only when the right arm could not be used. The appropriate BP cuff, 1 of 4 cuff sizes supported by the Omron 907XL, was used based on direct measurement of the upper midarm circumference which was measured once after consent was obtained. Participants were instructed to empty their bladder before the start of the study. For all BP measurements, they sat in a chair with back support, with both uncrossed feet resting comfortably on the floor, and with their forearm supported on a level surface. The BP device was placed near the participant, who was unable to see the measurements. Participants were provided with their average BP at the completion of the study visit with guidance regarding provider follow-up.

All measurements were attended by a research nurse who recorded the BP measurements. A research assistant timed each study procedure (walk, wait and rest time periods, and duration of and time between each BP measurement) to determine the total time required for BP measurement after each rest period.

Other Data Collection

Height, weight, medical history, and current medications were self-reported. If unknown, study staff would refer to the participant's medical record when available. Arm circumference was measured by research staff at the midpoint between the acromion and the olecranon at the time of consent.

Sample Size Calculations

We considered the difference between 5 minutes$_1$ and 5 minutes$_2$ to reflect intrinsic BP variability and designed the trial to test whether the difference between resting 0 minutes or 2 minutes with 5 minutes$_1$ was within a prespecified noninferiority margin of ±2 mm Hg compared with the difference between 5 minutes$_1$ and 5 minutes$_2$. Assuming that the SD for the difference between 5 minutes$_1$ and 5 minutes$_2$ is 12 mm Hg, we determined the required sample size to prove noninferiority of BP measurements obtained after shorter rest periods was n=111 with alpha=0.05 and power of 80%.

Statistical Analysis

Stata version 15 (StataCorp, College Station, TX) was used for all analyses. Mean and SD values were calculated for continuous data, and frequencies (n, %) were calculated for categorical variables.

Using the mean of triplicate BP measurements for each rest period, we first quantified the mean of the absolute difference between each participant's BP obtained during 5 minutes$_1$ and the other rest periods: 5 minutes$_1$–5 minutes$_2$ (Δ difference [Diff] 5 [the referent difference]), 5 minutes$_1$–2 minutes (Δ Diff 2), and 5 minutes$_1$–0 minutes (Δ Diff 0). To determine if resting 0 minutes or 2 minutes was noninferior to 5 minutes$_1$, the difference of differences was calculated (Δ Diff 5–Δ Diff 2 and Δ Diff 5–Δ Diff 0), with a difference, including the corresponding 95% CI, not exceeding ±2 mm Hg considered noninferior. Analyses

were done for the population overall and stratified by BP (systolic BP [SBP] $\geq$140 versus <140 mm Hg; diastolic BP [DBP] $\geq$90 versus <90 mm Hg). To visualize the degree of BP differences across the range of BP, we prepared Bland-Altman plots to display BP differences (eg, Δ Diff 5) on the y axis and the average of 2 BPs (eg, 5 minutes$_1$ and 5 minutes$_2$) on the x axis.

To determine if the variability of the 3 BPs in each set of triplicate measurements differed by rest period, we calculated the intraindividual coefficient of variation (SD/mean) of the 3 systolic and diastolic BPs obtained after each rest period and compared the coefficient of variations of each rest period (0 minutes, 2 minutes, 5 minutes$_1$, and 5 minutes$_2$).

Finally, the time to complete each BP measurement step was calculated for each rest period. Paired t tests compared the completion time between 0 minutes and 5 minutes$_1$, and 2 minutes and 5 minutes$_1$.

RESULTS

Of the 116 enrolled participants, 113 had all 4 sets of triplicate BP measurements. Three individuals had missing

Table 1. Characteristics of the 113 Enrolled Participants Who Completed All Triplicate Measurements

Characteristic	Mean (± SD) or n (%)
Age	55 (16)
Age <60 y	57 (50)
Male sex	41 (36)
Black race	84 (74)
Self-reported hypertension diagnosis	64 (57)
SBP ≥140 mm Hg	31 (27)
Mean SBP among SBP ≥140	153 (7.1)
DBP ≥90 mm Hg	14 (12)
Mean DBP among DBP ≥90	96 (4.6)
On antihypertensive medications	62 (55)
Diabetes diagnosis	22 (20)
Chronic kidney disease diagnosis	1 (0.9)
History of cardiovascular disease*	13 (12)
History of chronic pain	30 (27)
Weight (self-report kg)	88 (25)
Arm circumference, cm	34 (5.8)
Blood pressure cuff size	
Regular adult (22–32 cm)	39 (35)
Large adult (32–42 cm)	62 (55)
Extra large adult (42–50 cm)	12 (11)
Randomization group†	
Group 1 (0-2-5-5)	18 (16)
Group 2 (0-5-2-5)	18 (16)
Group 3 (2-0-5-5)	20 (18)
Group 4 (2-5-0-5)	18 (16)
Group 5 (5-0-2-5)	20 (18)
Group 6 (5-2-0-5)	19 (17)

DBP indicates diastolic blood pressure; and SBP, systolic blood pressure.
*History of heart attack, stroke, heart disease, or current use of pacemaker.
†Numbers in parentheses reflect order of rest periods.

Table 2. Mean BP After Each Rest Period and Absolute Difference in BP When Initial Rest Period Is Shorter than the Reference of 5 min (5 min$_1$)

BP Assessed	Strata based on level of systolic or diastolic BP	BP after 5-min rest$_1$*	BP after 5-min rest$_2$	BP after 2-min rest	BP after 0-min rest	Δ Diff 5 Absolute difference in BP (SD) 5-min rest$_1$ −5-min rest$_2$
SBP, mm Hg	Overall (N=113)	127.6 (19.6)	127.0 (19.7)	127.0 (19.1)	126.7 (19.0)	5.3 (4.7)
	SBP ≥140 mm Hg (n=31)	151.3 (11.3)	153.1 (7.1)	149.6 (12.5)	150.2 (11.5)	5.8 (6.2)
	SBP <140 mm Hg (n=82)	118.6 (13.7)	117.1 (12.7)	118.4 (13.2)	117.8 (12.7)	5.1 (4.0)
	DBP ≥90 mm Hg (n=14)	151.7 (10.5)	148.5 (10.4)	146.9 (14.6)	147.8 (13.2)	6.0 (3.9)
	DBP <90 mm Hg (n=102)	124.2 (18.2)	123.9 (18.9)	124.2 (18.0)	123.7 (17.8)	5.2 (4.8)
DBP, mm Hg	Overall (N=113)	74.7 (12.8)	75.6 (11.9)	73.8 (11.0)	74.1 (11.5)	3.0 (2.5)
	SBP ≥140 mm Hg (n=31)	84.1 (12.5)	85.3 (10.8)	82.1 (10.9)	83.1 (11.5)	3.3 (3.1)
	SBP <140 mm Hg (n=82)	71.2 (10.6)	72.0 (10.2)	70.7 (9.4)	70.7 (9.4)	2.8 (2.3)
	DBP ≥90 mm Hg (n=14)	95.6 (6.9)	96.4 (4.6)	90.0 (7.6)	92.3 (7.3)	3.6 (3.1)
	DBP <90 mm Hg (n=102)	71.8 (10.1)	72.7 (9.4)	71.5 (9.4)	71.5 (9.4)	2.9 (2.5)

(Continued)

data related to operator error and were not included in the analyses. The mean age of the 113 participants was 55 (SD, 16) years. Approximately, a third of participants were male, three-quarters were Black, and half were taking an antihypertensive medication (Table 1).

BP Levels and Differences Between Rest Periods

The overall mean BP after each rest period was similar (Table 2); mean SBP ranged from 126.7 to 127.6 mm Hg, and mean DBP ranged from 73.8 to 75.6 mm Hg. However, when the mean BP was stratified by BP level, differences by rest period were slightly greater. Specifically, among those with SBP ≥140 mm Hg, BP after 5 minutes$_1$ (reference) was 151/84, after 5 minutes$_2$ was 153/85, after 2 minutes was 150/82, and after 0 minute was 150/83. Among those with SBP <140 mm Hg, BP after 5 minutes$_1$ (reference) was 119/71, after 5 minutes$_2$ was 117/72, after 2 minutes was 118/71, and after 0 minutes was 118/71.

The average absolute difference between 5 minutes$_1$ and 5 minutes$_2$ (Δ Diff 5) was 5.3 mm Hg for SBP and 3.0 mm Hg for DBP (Table 2). The absolute difference between 2 minutes and 5 minutes$_1$ rest (Δ Diff 2) was significantly higher than the referent difference (Δ Diff 5; P=0.003 for SBP and P=0.002 for DBP), but this was not the case for the absolute difference between 0 minute and 5 minutes$_1$ (Δ Diff 0; P=0.704 for SBP and P=0.148 for DBP). With Δ Diff 5 as the reference, the absolute SBP difference and its 95% confidence interval (95% CI) did not cross our prespecified noninferiority margin for 0-minute rest (0.2 [95% CI, 0.8–1.2]) but did cross the margin for 2 minutes rest (−1.7 mm Hg [−2.8 to −0.6]). For the 82 participants with SBP <140, the absolute difference for both 0 and 2 minutes did not cross the margin of ±2 mm Hg: Δ Diff 5−Δ Diff 2 was −1.0 (95% CI, −2.0 to 0.1) for SBP and −1.0 (95% CI,

−1.7 to −0.2) for DBP; and Δ Diff 5−Δ Diff 0 was 0.8 (95% CI, −0.1 to 1.7) for SBP and −0.2 (95% CI, −0.9 to 0.5) for DBP (all mm Hg). Those with SBP ≥140 or DBP ≥90 had differences that exceeded our threshold for noninferiority (Table 2). Bland-Altman plots reveal a splaying of results at the more extreme BPs with shorter rest times (Figure [A] through [C]).

The first BP measured during each set of triplicate BPs were slightly higher than the mean measurements in each rest period (+0.4–1.8 mm Hg). When using only this first BP, the difference of differences between resting 5 minutes and 0 minutes did not reach our threshold for inferiority for those with SBP <140 mm Hg but did reach this threshold when SBP ≥140 mm Hg. Interestingly, the first BP measurement taken after 2 minutes of rest was not noninferior to the measurement taken after 5 minutes of rest for all strata (Table S1 in the Data Supplement).

BP Variability and Time

Variability between the 3 BP measurements in each triplicate set was not significantly different whether a participant rested for 0, 2, or 5 minutes. Specifically, there was no significant difference in mean intraindividual coefficient of variation between the measurements obtained after different rest periods (Table 3).

Overall, the time from initiation of measurements to completion of all 3 BP measurements was 4.5 minutes, whereas the total length of time for the entire procedure from sitting in the chair to completion of the third measurement was 4.5 minutes (0-minute rest period), 6.5 minutes (2-minute rest period), and 9.5 minutes (5-minute rest period; Table 4).

DISCUSSION

In this randomized trial of community-dwelling adults, triplicate BP measurements obtained after shorter (2

Table 2. **Continued**

Δ Diff 2 absolute difference in BP (SD) 5-min rest$_1$−2-min rest	P value comparing Δ diff 2 to Δ diff 5	Δ Diff 0 absolute difference in BP (SD) 5-min rest$_1$−0-min rest	P value comparing Δ diff 0 to Δ diff 5	Mean Δ diff 5 − Δ diff 2 (95% CI)	Mean Δ diff 5 − Δ diff 0 (95% CI)
7.0 (6.1)	0.003	5.1 (4.6)	0.704	−1.7 (−2.8 to −0.6)	0.2 (−0.8 to 1.2)
9.3 (7.6)	0.022	7.2 (6.0)	0.300	−3.5 (−6.5 to −0.5)	−1.4 (−4.0 to 1.3)
6.1 (5.2)	0.068	4.4 (3.7)	0.091	−1.0 (−2.0 to 0.1)	0.8 (−0.1 to 1.7)
10.7 (8.5)	0.043	7.7 (7.2)	0.306	−4.7 (−9.2 to −0.2)	−1.7 (−5.2 to 1.8)
6.4 (5.5)	0.028	4.8 (4.0)	0.371	−1.3 (−2.5 to −0.2)	0.3 (−0.7 to 1.3)
4.1 (4.1)	0.002	3.4 (3.0)	0.148	−1.1 (−1.8 to −0.4)	−0.5 (−1.1 to 0.2)
4.9 (5.9)	0.096	4.5 (3.9)	0.134	−1.6 (−3.5 to 0.3)	−1.2 (−2.8 to 0.4)
3.8 (3.2)	0.009	3.0 (2.5)	0.550	−1.0 (−1.7 to −0.2)	−0.2 (−0.9 to 0.5)
7.2 (7.5)	0.056	5.9 (5.5)	0.162	−3.5 (−7.2 to 0.1)	−2.2 (−5.4 to 1.0)
3.7 (3.2)	0.018	3.1 (2.3)	0.451	−0.8 (−1.4 to −0.1)	−0.2 (−0.8 to 0.4)

BP indicates blood pressure; DBP, diastolic blood pressure; and SBP, systolic blood pressure.
*Reference BP.

minutes) and no (0 minutes) rest periods resulted in minimally different BP values than those obtained after 5 minutes of rest. Importantly, for individuals with SBP <140 mm Hg, shorter or no rest before measurements provide BP values that are comparable to and noninferior to those obtained after a full 5 minutes of rest. There was no increase in intraindividual BP measurements with shorter rest periods (2 or 0 minutes), and there was no significant difference in time to obtain a measurement outside of the inherent difference introduced by the different rest times. These findings suggest that for the majority of individuals, most of whom do not have hypertension, measuring BP immediately after cuff placement provides a reasonable estimate of BP and could significantly reduce the time spent in screening for hypertension by ≈5 minutes (9.5 minutes with 5-minute rest versus 4.5 minutes with 0-minute rest).

Our findings challenge prior evidence suggesting the need for longer rest times before BP measurement. As detailed in a recent publication,[7] the guideline-recommended initial rest period was derived from evidence detailed in 2 studies of hypertensive adults comparing the effect of waiting 5 versus 10 minutes and 2 versus 16 minutes on seated BP.[8,9] Neither study randomized participants to rest order but instead employed a fixed rest order for all participants with shorter rest periods occurring first. Together, these studies revealed that an insufficient rest period resulted in a falsely elevated BP, with an estimated effect of +4.2 to 11.6 mm Hg systolic and +1.8 to 4.3 mm Hg diastolic.[7,10] However, several aspects of these studies raise concerns about their clinical applicability. First, the comparator rest periods (ie, 10 or 16 minutes) in these studies are much greater than what could be reasonably accomplished in a clinical setting. Second, only one of these studies examined the impact of rest on mean duplicate BP when using an automated device; the other examined one BP obtained at each rest period via manual auscultation with a mercury manometer[9] which may not be as generalizable to clinics relying on automated devices for measurement. Third, these studies focused on a population of adults with hypertension and did not provide evidence regarding the effect of rest times among those without hypertension. One randomized clinical trial that did investigate the effect of rest on BP among normotensive individuals using a cross-over study design showed that BP measured after 5 minutes of rest was significantly different than BP measured after 0 minutes of rest.[11] However, this study was conducted in a select population of adults who were 50 years of age and older in a cardiac rehabilitation facility (indicating the presence of cardiovascular disease) and did not have a washout period between rest time assignments.

Other studies have described that unattended automated office BP measurements (AOBP) without antecedent rest were similar to wake measurements obtained by ambulatory BP monitoring (ABPM), with BP differences ranging from 1 to 4 mm Hg.[12] A recently published trial[13] demonstrated that the mean triplicate BP obtained by unattended AOBP after 0 minutes rest was closer to mean wake ABPM measurements than were the mean AOBPs obtained after 5 minutes of rest. The differences were −0.02 (17.4) for 0 minutes rest and −5.2 (18.6) for 5 minutes rest, with negative numbers indicating the AOBP was lower. There was a different magnitude and direction of differences when individuals were stratified by SBP: when SBP<130 mm Hg, AOBP was lower than ABPM, and when SBP≥130 mm Hg, AOBP was higher than daytime ABPM. Notably, study participants were recruited from clinics where they had been referred for ABPM to either confirm a diagnosis of hypertension or evaluate treatment of hypertension.

Whereas resting for 0 minutes before BP measurement met our criteria for noninferiority overall, resting for
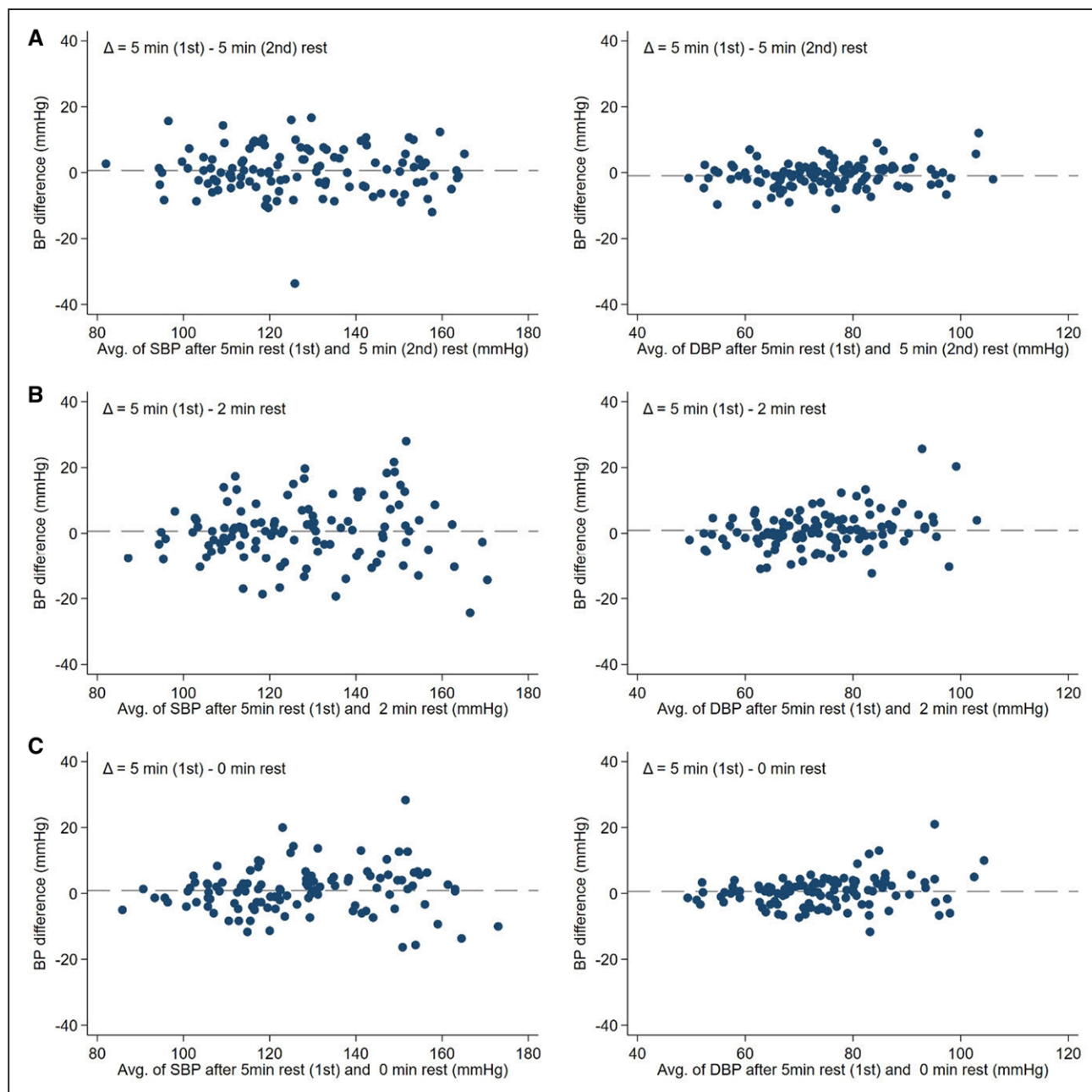
Figure. A–C, Bland-Altman plots depicting the degree of BP differences across the range of BP after (A) 5 min of rest, (B) 2 min of rest, and (C) 0 min of rest.

2 minutes did not meet these same criteria for all individuals. This finding was unexpected. Notably, for those with SBP <140 mm Hg, both shorter rest periods produced BP measurements that were noninferior to BPs obtained after resting for 5 minutes. In this context, potential explanations for the observed difference between the two shorter rest periods may be related to age, hypertension status, and antihypertensive medication use impacting cardiovascular response to light activity. Specifically, older, hypertensive individuals on antihypertensive medications may have a delayed response to walking that is borne out at 2 minutes and not immediately at 0 minutes. This finding warrants replication.

As expected, the BP measurements for each rest period were slightly higher overall when using the first measurement versus the mean of triplicate measurements. Single BPs obtained after 5 minutes of rest were noninferior to single BPs obtained after no rest for those with SBP<140 mm Hg, but our results did not support noninferiority of measurements obtained after 2 minutes of rest. As above, this warrants replication. However, these findings suggest that triplicate BP measurements after minimal rest may provide the ideal balance of efficiency and accuracy when resources are limited.

Our results suggest a potential strategy to streamline and shorten hypertension screening efforts. Specifically,

Table 3. Measures of Intraindividual Variability of Triplicate BP by Initial Rest Period

BP assessed	Group examined	Coefficient of variability (%)				P value			
		BP 5-min rest$_1$	BP 5-min rest$_2$	BP 2-min rest	BP 0-min rest	5$_1$ vs 5$_2$	5$_1$ vs 2	5$_1$ vs 0	ANOVA
SBP, mm Hg	Overall (N=113)	4.6 (2.5)	4.1 (2.5)	4.4 (2.8)	4.6 (3.3)	0.102	0.538	0.957	0.472
	SBP≥140 mm Hg (n=31)	4.8 (2.5)	3.9 (3.1)	4.1 (2.6)	3.6 (2.2)	0.175	0.306	0.03	0.308
	SBP<140 mm Hg (n=82)	4.5 (2.5)	4.1 (2.3)	4.5 (2.8)	5.0 (3.6)	0.301	0.947	0.181	0.293
	DBP≥90 mm Hg (n=14)	5.0 (2.5)	4.1 (2.7)	5.9 (2.6)	3.5 (2.6)	0.393	0.273	0.083	0.093
	DBP<90 mm Hg (n=99)	4.5 (2.5)	4.1 (2.5)	4.2 (2.7)	4.8 (3.4)	0.164	0.33	0.491	0.287
DBP, mm Hg	Overall (N=113)	4.7 (4.0)	4.1 (4.0)	4.5 (3.1)	4.7 (3.5)	0.305	0.735	0.908	0.608
	SBP≥140 mm Hg (n=31)	4.4 (3.3)	3.4 (2.2)	5.0 (2.7)	4.2 (2.9)	0.135	0.421	0.769	0.144
	SBP<140 mm Hg (n=82)	4.8 (4.3)	4.4 (4.4)	4.4 (3.3)	4.9 (3.7)	0.606	0.404	0.747	0.762
	DBP≥90 mm Hg (n=14)	4.7 (3.6)	3.5 (1.9)	5.5 (3.2)	4.3 (3.7)	0.267	0.438	0.817	0.432
	DBP<90 mm Hg (n=99)	4.7 (4.1)	4.2 (4.2)	4.4 (3.1)	4.8 (3.5)	0.437	0.535	0.806	0.708

BP indicates blood pressure; DBP, diastolic blood pressure; and SBP, systolic blood pressure.

all individuals presenting for hypertension screening can have BP measurement initiated immediately, without antecedent rest before cuff inflation. Individuals with an average SBP<140 mm Hg can have their screening measurements completed in <5 minutes. Those with an average SBP≥140 mm Hg would need to have their BP measurement repeated which could be completed immediately after the initial triplicate measurement; the average of the second triplicate measurement would then be used for clinical decision-making. Knowing that the initial 3 BPs taken after no rest should take 4.5 minutes, individuals requiring the second set of triplicate measurements would not add any more time to the hypertension screening encounter than if the 5 minutes of rest was employed for all. Instead, those with SBP<140 mm Hg, typically the largest group of persons who attend BP screenings, could complete their screening measurements in half of the time.

In this regard, our findings are relevant to large-scale, BP screening programs, such as the International Society of Hypertension's May Measurement Month, which has measured BP in over 4.2 million persons.[14–17] These screening efforts are often limited by personnel resources and time. Low-resource settings are particularly constrained, with "high provider workload and limited time to perform proper measurement" cited as key challenges to optimal BP measurement by the Lancet Commission on Hypertension Group.[18] Eliminating the need for long rest periods before most BP measurements not only simplifies screening procedures, but is less resource intensive, allowing personnel to either screen more individuals or perform other clinical tasks. Implementing shorter resting periods for the majority of patients, such as by only asking patients to rest for 5 minutes when their initial SBP is ≥140 mm Hg, could substantially shorten screening times: <5 minutes for most versus almost 10

Table 4. Elapsed Time from Cuff Inflation to Completion of Measurement for each triplicate BP Determination, Stratified by Initial Rest Period

BP measurement steps in sequential order	Rest time in seconds, mean (SD)			Paired t test	
	0 min	2 min (120 s)	5 min (300 s)	P value (5 vs 0 min)	P value (5 vs 2 min)
Seating	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	.	.
Seating→completion of cuff placement	16.3 (5.9)	17.8 (11.7)	17.2 (5.8)	0.136	0.609
Cuff placement→start of first cuff inflation	3.2 (4.1)	122.6 (4.5)	302.1 (1.8)	<0.001	<0.001
Cuff placement→start of first cuff inflation minus the assigned rest time in seconds	3.2 (4.1)	2.6 (4.5)	2.1 (1.8)	0.007	0.230
Cuff inflation→completion of first measurement	42.2 (15.2)	40.0 (10.6)	40.1 (12.3)	0.106	0.883
Completion of first measurement→start of second cuff inflation	64.4 (2.5)	64.0 (4.3)	64.6 (2.3)	0.030	0.089
Cuff inflation→completion of second measurement	38.7 (8.8)	38.5 (8.7)	38.2 (8.2)	0.300	0.563
Completion of second measurement→start of third cuff inflation	64.0 (6.1)	64.0 (5.1)	64.6 (2.2)	0.286	0.206
Cuff inflation→completion of third measurement	38.9 (8.6)	38.1 (9.5)	38.5 (8.6)	0.313	0.545
Completion of third measurement→cuff removal	5.9 (1.4)	6.4 (3.9)	7.0 (8.0)	0.141	0.436
Overall: time from seating to complete the 3 BP measurements (minus the initial rest time)	273.6 (35.5)	271.4 (36.8)	272.5 (34.2)	0.562	0.569

BP indicates blood pressure.

minutes for all. Assuming that 30% of individuals presenting for screening have an initial SBP≥140 mm Hg, implementing this screening strategy could lead to 48 more individuals screened over a 12-hour period by a single observer, that is, 120 versus 72 people screened per day ([10 minutes×30%]+[5 minutes×70%] versus [10 minutes×100%]). Over a week, this would translate to 336 more individuals screened, dramatically increasing the numbers of hypertensive individuals identified and treated.

It also follows that simplifying the BP measurement process may make it easier for providers to adhere to the other essential BP measurement steps such as patient positioning and cuff placement. There are 11 key steps to complete before even taking a BP measurement, with few providers completing all steps at each patient encounter. A study of US medical students revealed that on average, only 4 of these 11 steps were consistently completed by observers, with resting for 5 minutes before BP measurement completed least frequently (7% of the time).[19] Although it remains to be seen if eliminating the rest period for most patients does in fact make it easier to complete the other steps more consistently, a study showing a more robust adherence to rest (70% of the time) when the recommended period was a range between 2-5 minutes suggests the potential impact of this approach.[20]

Our study has several limitations. We studied the effect of shorter rest periods on triplicate BP measurements which, although recommended by clinical practice guidelines, may not be uniformly employed in clinical and screening settings. Second, we studied BP measurements obtained in a quiet, private research setting by research staff. This setting may not adequately replicate clinical and screening settings, which may not be private or quiet, and may have added stress associated with impending clinical care. The BP response to various rest periods may not be the same in these different settings. Third, we did not have adequate sample size to further explore the different results after resting for 0 and 2 minutes among those with higher BPs. Finally, our study aim was to determine the effect of rest time on BPs obtained for hypertension screening; therefore, it may not be appropriate to extrapolate our results to research studies in which precision is desired to investigate the effects of interventions.

Our study also has several strengths. First, our study population was community-dwelling individuals with a wide range of BPs and was diverse in terms of age, sex, race, and comorbidities, enhancing the generalizability of results. Second, we measured BP according to standardized methods endorsed by professional societies, using a validated automated device as is typically used in clinical and screening environments. Third, the BP measurement protocol for each rest period replicated a typical screening or clinical encounter with time for sitting and

a short walk to the BP measurement room. Fourth, recognizing the inherent variability of BP within individuals, we obtained triplicate BPs after 5 minutes of rest twice in each participant and utilized the absolute difference of differences as our outcome measure.

In conclusion, in this trial of community-dwelling adults, BPs obtained after shorter rest periods were non-inferior than those obtained after 5 minutes of rest when the SBP was <140 mm Hg. This suggests shorter rest times, even no rest, may be reasonable for screening, with 5 minutes of rest only implemented when average SBP is ≥140 mm Hg. These findings could improve the efficiency of hypertension screening, especially in resource-constrained settings, by offering a streamlined workflow and less time investment for the majority of patients.

PERSPECTIVES

This randomized clinical trial challenges the guideline recommendation that all individuals require antecedent rest before BP measurement. Individuals with SBP<140 mm Hg, who comprise the majority of individuals presenting for hypertension screening, could have BP measurements initiated immediately, decreasing the time required to screen them by half. Eliminating the need for long rest periods before most BP measurements not only simplifies screening procedures but is less resource intensive, allowing personnel to dramatically increase the numbers of hypertensive individuals identified and treated. Implementing this approach on a broad scale could potentially increase screening volume by ≈60%. Recognizing that unique aspects to large-scale screening efforts (eg, talking, smartphone use, loud environment, patient positioning, cuff size) may also affect BP measurements, future studies should assess the effects of environment and other factors on BP measurements.

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