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Clinical relevance of double-arm blood pressure measurement and prevalence of clinically important inter-arm blood pressure differences in Indian primary care

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Abstract

Hypertension guidelines recommend measuring blood pressure (BP) in both arms at least once. However, this is seldom done due to uncertainties regarding measurement procedure and the implications of finding a clinically important inter-arm BP difference (IAD). This study aimed to provide insight into the prevalence of clinically important IADs in a large Indian primary care cohort.

A number of 134 678 (37% female) unselected Indian primary care participants, mean age 45.2 (SD 11.9) years, had BP measured in both arms using a standardized, triplicate, automated simultaneous measurement method (Microlife WatchBP Office Afib).

On average, there were clinically minor differences in right and left arm BP values: systolic BP 134.4 vs 134.2 mmHg ($p < .01$) and diastolic BP 82.7 vs 82.6 mmHg ($p < .01$), respectively.

Prevalence of significant mean systolic IAD between 10 and 15 mmHg was 7,813 (5.8%). Systolic IAD ≥ 15 mmHg 2,980 (2.2%) and diastolic IAD ≥ 10 mmHg 7,151 (5.3%). In total, there were 7,595 (5.6%) and 8,548 (6.3%) participants with BP above the 140/90 mmHg threshold in only the left or right arm, respectively. Prevalence of participants with elevated BP on one arm only was highest in patients with a systolic IAD ≥ 15 mmHg; 19.1% and 13.7%, for left and right arm, respectively.

This study shows that a substantial prevalence of IAD exists in Indian primary care patients. BP is above the diagnostic threshold for hypertension in one arm only for 6% of participants. These findings emphasize the importance of undertaking bilateral BP measurement in routine clinical practice.

KEYWORDS
blood pressure, cardiovascular disease, hypertension, inter-arm blood pressure difference

1 INTRODUCTION

Recent hypertension management guidelines for Europe, USA, UK, and Canada recommend blood pressure (BP) measurement in both arms when assessing a patient for hypertension at a first visit.[1–4] Inter-arm differences (IAD) in BP have been associated with peripheral arterial disease and increased cardiovascular and all-cause mortality.[5,6] Despite these recommendations, bilateral BP measurements are often not performed in routine clinical practice.[7–9] This may be due to uncertainties around appropriate methods of bilateral BP measurement and correct interpretation and management of an IAD.[10]

There is some discrepancy between hypertension guidelines in different parts of the world with regard to what is considered as a clinically relevant IAD. UK National Institute of Health and Care Excellence (NICE) guidelines and European Society of Hypertension (ESH) guidelines recommend, based on findings from meta-analyses,[5,10] that a systolic IAD ≥ 15 mmHg is 'suggestive of atheromatous disease[11]' The recently published American College of Cardiology (ACC) guidelines suggest that clinicians should 'verify that left/right inter-arm differences are insignificant' and, if an IAD is present, the higher reading arm should be used for subsequent BP readings.[1] The Canadian hypertension program specifies that a systolic IAD of 10 mmHg or more is significant.[12] Both the Indian and Japanese Society of Hypertension guidelines state that BP must be checked in both arms, without further specifications.[13]

The measurement method for detecting an IAD is also unclear, despite guidelines highlighting its important role in hypertension measurement and ongoing management.[14] ESC guidelines suggest that IADs should be determined preferably by simultaneous, double-arm BP measurement. This recommendation is based on the findings of some studies showing that sequential measurements can overestimate IAD compared with simultaneous BP measurements, risking unnecessary referrals and unnecessary procedures.[14–17] However, recent evidence has confirmed the prognostic value of sequentially measured arm BPs.[6]

The purpose of this study was to 1) determine the prevalence of absolute IADs in BP in a large representative primary care cohort in India, 2) compare prevalence's of IAD with clinically significant IAD cutoff values recommended in international BP guidelines and existing literature, and 3) determine the relationship between IADs and patient characteristics.

2 | METHODS

2.1 | Study design and participants

In this cross-sectional study, participants were randomly selected patients from 2400 primary practice centers across India from January 2018 to February 2019. BP was measured by physician assistants, immediately prior to consultation with primary care physicians, after a minimum of 5 minutes of seated rest, with appropriately sized cuffs and both arms supported and positioned at the level of the heart. Both upper arms were measured simultaneously using a validated, automatic, electronic sphygmomanometer (Microlife WatchBP Office AFIB, Microlife AG, Switzerland).[18–21] This device incorporates a novel algorithm for BP measurement in AF to overcome some of the inherent inaccuracy in oscillometric measurement in atrial fibrillation (AF)[22] and also issues 'alerts' when potential AF is detected. Recommendations from current ESH guidelines for preparation and positioning for BP measurement were followed.[11] Using the device, three consecutive bilateral BP readings were automatically taken at 1-minute intervals, and the mean of the three systolic and diastolic BPs were reported for both arms.

2.2 | Patient data

After written informed consent was obtained, the following patient data were extracted from participant medical records: age, sex, alcohol use, lipid values, smoking status, and diagnosis of diabetes mellitus (Type 1 and 2) or hypertension. The study protocol was approved by Rippon Independent Ethics Committee (registration number: ECR/299/Indt/TN/2018/RR-21), Chennai, Tamil Nadu, India.

2.3 | Statistical analysis

Systolic and diastolic IAD were calculated as mean right arm minus mean left arm BP. Mean and standard deviation (SD) values of IAD (ie, right minus left arm difference) and absolute IAD values were calculated and reported with other baseline demographics. Subsequently, participant characteristics were compared according to predefined commonly cited cut-off points of absolute systolic and diastolic inter-arm differences, namely, 5, 10, and 15 mmHg. Proportions of participants with systolic BP higher on the right and on the left arms were calculated, and the prevalence of hypertension (defined as SBP $\geq$ 140 mmHg and/or DBP $\geq$ 90 mmHg) in one arm, but normotension (< 140/90 mmHg) in the other arm, was determined.

An additional separate analysis was performed to compare patients' characteristics of patients who received an AF alert during BP measurement with those who did not receive such an alert.

Multivariable linear regressions were performed to explore association of absolute systolic and diastolic IADs. Candidate variables were pre-specified as age, sex, hypertension, diabetes mellitus, highest SBP of both arms, highest DBP of both arms, heart rate, dyslipidemia, and AF alert. Results are presented as β coefficients and associated 95% confidence intervals (CI); statistical significance was accepted at $p < .05$.

Main demographic and clinical data were summarized according to systolic thresholds $\geq$ 5, 10, and 15 mmHg reporting means $\pm$ SD for continuous variables and the absolute (n) and relative (%) frequencies for categorical variables. Differences across groups were evaluated by analysis of variance or Chi-square test, depending on the type of variable. Data analysis was performed using RStudio Version 1.2.5033 for Windows.

3 | RESULTS

3.1 | Demographics and prevalence of inter-arm differences in blood pressure

The study enrolled 134 678 persons with a mean age of (standard deviation, SD) 45.2 (11.9) years; 49 757 (36.9%) were females (Table 1). Overall, both systolic BP (134.4 (16.3) vs 134.2 (16.2) mmHg; $p < .01$) and diastolic BP (82.7 (10.0) vs 82.6 (10.2) mmHg; $p < .01$) were marginally higher on the right arm compared to the left arm. Mean IAD (right minus left arm) was .2 (6.2) mmHg and .1 (5.4) mmHg for systolic and diastolic BP (Figure 1A and 1B). Approximately 36% of participants had a systolic IAD $\geq$ 5 mmHg and 8.0 % had a systolic IAD $\geq$ 10 mmHg. On average, absolute systolic and diastolic IAD were 4.4 (4.4) mmHg and 3.5 (4.1) mmHg, respectively. Comparison of participants grouped according to 5 mmHg increments of systolic IAD showed a trend towards rising age, systolic and diastolic BPs, rising heart-rate, and rising prevalence of diabetes and hypertension ($p < .001$ for all comparisons). An IAD $\geq$ 5 mmHg was associated with more frequent AF alerts during blood pressure measurement, in comparison to those with a systolic IAD < 5 mmHg (Table 1).

In total, there were 16 143 (11.9%) patients who had elevated BP (ie, > 140/90 mmHg) on one arm only; 8548 (6.3%) patients had right arm hypertension and 7595 (5.6%) had left arm hypertension. These patients had mean BP values close to the threshold values of 140/90 mmHg (Supplementary table 1).

3.2 | Multivariable modeling

Multivariable analyses included all 134 678 participants with complete data in the final model. Factors positively associated with absolute systolic IAD were female sex, highest SBP and highest DBP, heart rate, alcohol use, and having an AF alert. Factors negatively associated with systolic IAD were male sex, smoking, diabetes, and dyslipidemia (Table 2). For absolute diastolic IAD, the model was similar apart from highest SBP and heart rate, which were negatively instead of positively associated with it. Adjusted R^2 for absolute systolic and diastolic IAD were .070 and .114, respectively.

TABLE 1 Patient characteristics separated for systolic inter-arm difference (IAD) cut-off levels

	<5 mmHg (No. = 85 705)	5-10 mmHg (No. = 38 180)	10-15 mmHg (No. = 7813)	> = 15 (No. = 2980)	Total (No. = 134 678)	*p* value
Gender						<.001
Female	31 892 (37.2%)	13 838 (36.2%)	2841 (36.4%)	1186 (39.8%)	49 757 (36.9%)	
Male	53 813 (62.8%)	24 342 (63.8%)	4972 (63.6%)	1794 (60.2%)	84 921 (63.1%)	
Age (yrs)						<.001
	44.7 (11.9)	45.7 (11.8)	47.2 (12.3)	48.3 (13.2)	45.2 (11.9)	
SBP left (mmHg)						<.001
	132.7 (15.0)	136.3 (17.0)	138.8 (19.0)	140.2 (22.6)	134.2 (16.2)	
SBP right (mmHg)						<.001
	133.0 (15.1)	136.5 (16.8)	138.1 (19.1)	140.0 (26.2)	134.4 (16.3)	
DBP left (mmHg)						<.001
	81.9 (9.5)	83.5 (10.1)	84.8 (11.7)	87.6 (18.0)	82.6 (10.2)	
DBP right (mmHg)						<.001
	82.1 (9.5)	83.6 (10.0)	84.1 (11.5)	85.3 (17.3)	82.7 (10.0)	
Heart rate (BPM)						<.001
	82.1 (12.0)	84.1 (12.3)	84.6 (13.4)	87.0 (14.2)	82.9 (12.3)	
IAD Absolute SBP (mmHg)						<.001
	2.2 (1.2)	6.3 (1.3)	11.2 (1.3)	22.7 (12.5)	4.4 (4.4)	
IAD SBP (mmHg)						<.001
	0.2 (2.5)	0.3 (6.4)	−0.6 (11.2)	−0.1 (25.9)	0.2 (6.2)	
IAD Absolute DBP (mmHg)						<.001
	2.7 (2.9)	4.1 (3.5)	6.1 (5.9)	10.0 (14.2)	3.5 (4.1)	
IAD DBP (mmHg)						<.001
	0.3 (4.0)	0.1 (5.4)	−0.7 (8.5)	−2.3 (17.2)	0.1 (5.4)	
IAD DBP (categorized)						<.001
< 10 mmHg	83 439 (97.4%)	36 015 (94.3%)	6131 (78.5%)	1942 (65.2%)	127 527 (94.7%)	
≥ 10 mmHg	2266 (2.6%)	2165 (5.7%)	1682 (21.5%)	1038 (34.8%)	7151 (5.3%)	
Diagnosis based on both arms						<.001
normotension	52 068 (60.8%)	17 154 (44.9%)	2549 (32.6%)	776 (26.0%)	72 547 (53.9%)	
left hypertension	2954 (3.4%)	2876 (7.5%)	1196 (15.3%)	569 (19.1%)	7595 (5.6%)	
right hypertension	3695 (4.3%)	3399 (8.9%)	1046 (13.4%)	408 (13.7%)	8548 (6.3%)	
hypertension both arms	26 988 (31.5%)	14 751 (38.6%)	3022 (38.7%)	1227 (41.2%)	45 988 (34.1%)	
Arm with higher SBP						<.001
identical	6420 (7.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	6420 (4.8%)	
left higher	34 836 (40.6%)	18 387 (48.2%)	4132 (52.9%)	1564 (52.5%)	58 919 (43.7%)	
right higher	44 449 (51.9%)	19 793 (51.8%)	3681 (47.1%)	1416 (47.5%)	69 339 (51.5%)	
Smoking						<.001
No	80 765 (94.2%)	35 550 (93.1%)	7306 (93.5%)	2846 (95.5%)	126 467 (93.9%)	
Yes	4940 (5.8%)	2630 (6.9%)	507 (6.5%)	134 (4.5%)	8211 (6.1%)	
Alcohol						<.001
No	81 032 (94.5%)	35 466 (92.9%)	7088 (90.7%)	2781 (93.3%)	126 367 (93.8%)	
Yes	4673 (5.5%)	2714 (7.1%)	725 (9.3%)	199 (6.7%)	8311 (6.2%)	

(Continues)

TABLE 1 (Continued)

	<5 mmHg (No. = 85 705)	5-10 mmHg (No. = 38 180)	10-15 mmHg (No. = 7813)	> = 15 (No. = 2980)	Total (No. = 134 678)	*p* value
Diabetes						<.001
No	75 634 (88.2%)	32 792 (85.9%)	6753 (86.4%)	2533 (85.0%)	117 712 (87.4%)	
Yes	10 071 (11.8%)	5388 (14.1%)	1060 (13.6%)	447 (15.0%)	16 966 (12.6%)	
Dyslipidemia						.269
No	85 103 (99.3%)	37 902 (99.3%)	7772 (99.5%)	2960 (99.3%)	133 737 (99.3%)	
Yes	602 (0.7%)	278 (0.7%)	41 (0.5%)	20 (0.7%)	941 (0.7%)	
AF alert						<.001
No	84 956 (99.1%)	36 878 (96.6%)	7602 (97.3%)	2918 (97.9%)	132 354 (98.3%)	
Yes	749 (0.9%)	1302 (3.4%)	211 (2.7%)	62 (2.1%)	2324 (1.7%)	

Additional analysis confirmed the positive association of a monitor generated AF alert with IAD: Patients who received an AF alert (n = 2234 [1.7%]) had significantly higher IAD values than those without such an alert for both systolic (6.2 ± 3.9 vs 4.4 ± 4.4) and diastolic (4.7 ± 3.5 vs 3.4 ± 4.0) BP, respectively. Patients with an AF alert were older, had higher BP and were relatively more often male. Half the patients with an AF alert showed an IAD value between 5 and 10 mmHg as compared to 20% for the patients without such an alert. From the latter group 75% had an IAD less than 5 mmHg as compared to only 20% of the group without an AF alert. However, due to the low prevalence of patients with an AF alert in the present study, this group had no significant influence on IAD values and/ or category prevalence values of the total population (Supplementary table 2).

4 | DISCUSSION

4.1 | Summary of main findings

This large cohort study demonstrates the importance of measuring BP in both arms; a systolic IAD ≥ 10 mmHg was found in more than 8% of persons. In total, 11.9% of participants had a BP > 140/90 mmHg in one arm but not in the other, suggesting that 6% of the cohort could be denied referral for further investigation to diagnose hypertension against this threshold if BP was only measured in one arm. Prevalence of recognized cardiovascular risk factors such as age, baseline BP, diabetes mellitus, and hypertension rose according to magnitude of systolic and diastolic IADs. A systolic IAD ≥ 5 mmHg was also associated with increased prevalence of BP monitor generated AF alerts independent of BP level.

4.2 | Strengths and limitations of the approach

To our knowledge, this is the largest cohort study published to date examining the prevalence and associations of an IAD in BP. There is uncertainty as to any ethnic influence on magnitude of IADs.[17] Although many previous studies have reported IAD prevalence estimates we have found relatively little previous data from the Indian subcontinent.[23–25]

Due to the observational design of the study, and practical limitations due to the cohort size, only a minimal amount of data was collected per patient. Therefore, the present study could only explore the relationship of IAD with a limited number of cardiovascular risk factors, and estimation of cardiovascular risk using recognized approaches such as the Framingham score and investigating the relation of IAD to hypertension-mediated organ damage was not possible.[26] Although the WatchBP Office device collects separate BP values for each of the three automated pairs of measurements, for practical reasons, only the mean BP values were extracted for research. Therefore, analysis of the impact of BP variability on IAD was not possible. This also led to the fact that the present data did not allow to verify how many persons had consistent IAD of more than 10 or 20 mmHg as is recommended by the 2021 European Society of Hypertension guidelines.[27] Nevertheless, we are of the opinion that the average BP values provide a reliable indication of the true IAD because it is based on the average of three automated BP measurements. Recent evidence showed that concordance of the higher BP arm-side was 63% overall, rising to 73% and 92% when the mean IAD was equal to or higher than 5 and 10 mmHg, respectively. This confirms consistency of IADs, especially where the average IAD was equal to or higher than 10 mmHg.[28] In addition, Clark and associates found in their meta-analysis that an IAD of 10 mmHg or more was associated with peripheral vascular disease. This finding was based on 20 studies of which the majority did not use the consistency method.[5] ECG confirmation of AF was not obtained when an AF alert was reported by the Watch BP Office device. Previous reports have shown high specificity but variable sensitivity of the device for AF confirmed by ECG.[29,30] Consequently, the associations of IAD with AF alerts are of interest but we are careful with drawing conclusions on the associations of AF with IAD.

4.3 | Relationship to existing literature

In the Indian literature, one community-based cross-sectional study carried out among 1634 adults in Anakaputhur, an urban area in

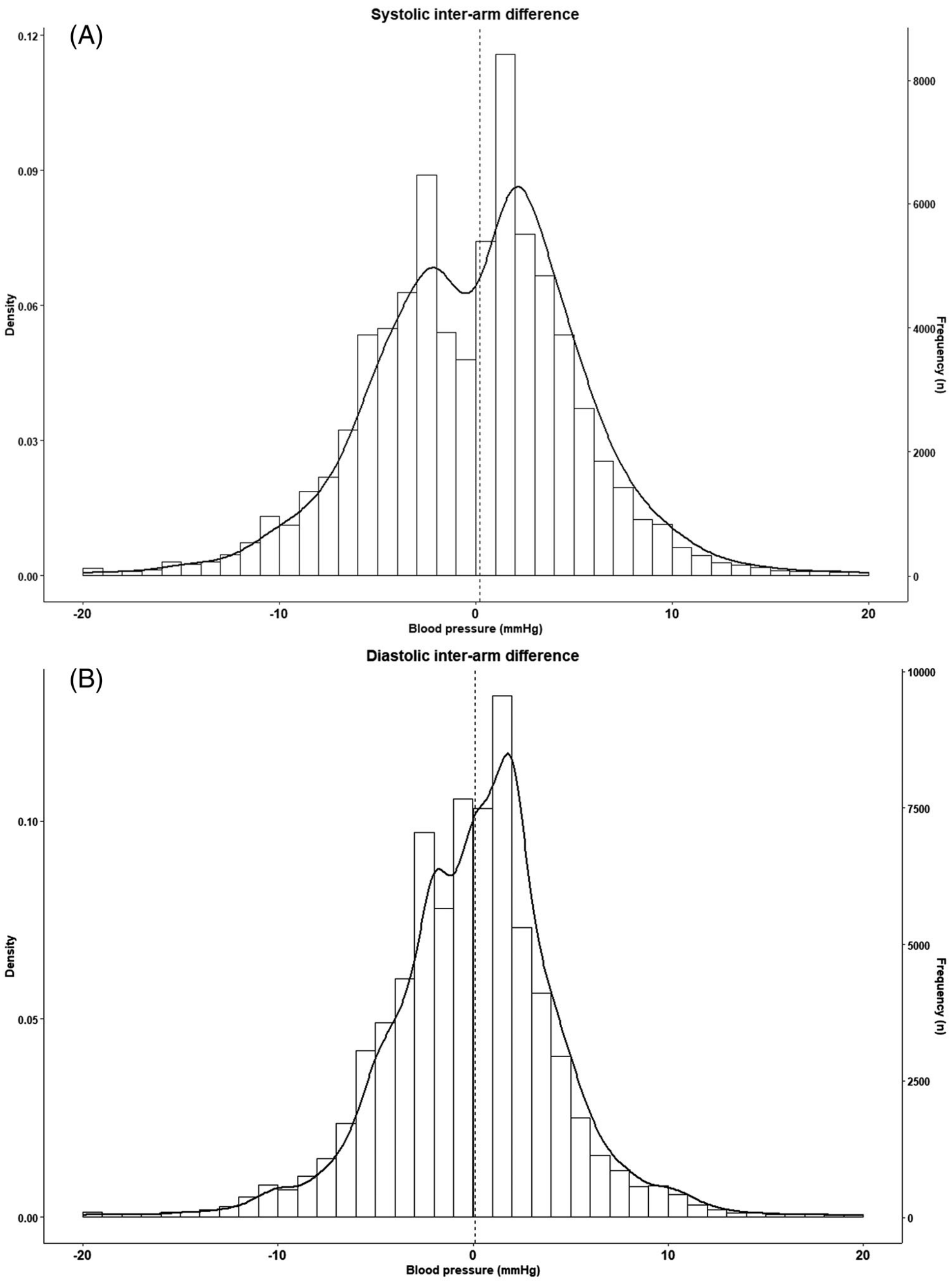

FIGURE 1 Histogram of systolic (A) and diastolic (B) inter-arm difference. Interarm difference was calculated as right-arm blood pressure minus left-arm blood pressure

Kancheepuram district of Tamil Nadu, reported much higher prevalences of systolic and diastolic IAD ≥ 10 mmHg (43.5% and 20.3%, respectively), and one other smaller study of 100 healthy medical students found that 29% had a systolic IAD ≥ 10 mmHg.[23,24] Both studies used a sequential manual measurement method. The lower prevalences reported in the current study are consistent with previous findings from our groups and others that observed IADs at any cut-off are less prevalent when simultaneous rather than sequential measurement methods are used, when automated devices are used in place of manual assessment, and when measures are repeated.[14,17,31,32]

The Microlife WatchBP Office device has been used in previous cohort studies finding comparable prevalences for a systolic IAD ≥ 10 mmHg of 9.1% (Denmark) and 10% (Germany) but 18% in an older age population in the Netherlands.[15,16,33] One other community study from Italy found 16.8% of participants had an IAD ≥ 10 mmHg for either systolic or diastolic BP.[34] The range of these previous reports is in line with the systolic IAD prevalence ≥ 10 mmHg of 8.1% found in the present study.

Clinical evidence has shown that a BP difference of 10 mmHg or more between arms identifies patients who need further vascular assessment.[5] However, this was mainly based on IAD taken

TABLE 2 Factors associated with inter-arm difference in multivariate models

	Systolic Absolute			Systolic			Diastolic absolute			Diastolic		
Predictors	*B*	*95% CIs*	*p-values*	*B*	*95% CIs*	*p-values*	*B*	*95% CIs*	*p-values*	*B*	*95% CIs*	*p-values*
(Intercept)	−6.29	−6.52 – −6.05	**<.001**	−1.15	−1.50 – −0.80	**<.001**	−6.49	−6.71 – −6.27	**<.001**	2.84	2.53 – 3.14	**<.001**
Gender (Male)	−0.25	−0.30 – −0.20	**<.001**	−0.04	−0.11 – 0.03	.259	−0.30	−0.34 – −0.25	**<.001**	0.15	0.09 – 0.21	**<.001**
Age (Years)	−0.00	−0.01 – −0.00	**<.001**	−0.01	−0.02 – −0.01	**<.001**	0.01	0.01 – 0.01	**<.001**	−0.01	−0.01 – −0.00	**<.001**
Highest SBP (mmHg)	0.06	0.06 – 0.06	**<.001**	−0.00	−0.01 – −0.00	**.024**	−0.02	−0.02 – −0.02	**<.001**	0.01	0.01 – 0.01	**<.001**
Highest DBP (mmHg)	0.02	0.02 – 0.02	**<.001**	0.03	0.03 – 0.03	**<.001**	0.16	0.15 – 0.16	**<.001**	−0.05	−0.05 – −0.04	**<.001**
Heart rate (bpm)	0.02	0.01 – 0.02	**<.001**	−0.00	−0.00 – 0.00	.385	−0.01	−0.01 – −0.00	**<.001**	−0.00	−0.00 – 0.00	.061
Smoking (Yes)	−0.31	−0.42 – −0.20	**<.001**	0.04	−0.13 – 0.21	.650	−0.25	−0.36 – −0.15	**<.001**	−0.02	−0.17 – 0.13	.792
Diabetes (Yes)	−0.12	−0.19 – −0.05	**.001**	−0.15	−0.25 – −0.05	**.004**	−0.22	−0.29 – −0.16	**<.001**	−0.09	−0.18 – −0.00	**.042**
Alcohol (Yes)	0.60	0.49 – 0.71	**<.001**	−0.44	−0.60 – −0.27	**<.001**	0.43	0.32 – 0.53	**<.001**	0.02	−0.12 – 0.17	.779
Dyslipidemia (Yes)	−0.51	−0.78 – −0.24	**<.001**	0.35	−0.05 – 0.74	.087	−0.32	−0.58 – −0.07	**.012**	0.44	0.09 – 0.78	**.014**
AF alert (Yes)	1.27	1.10 – 1.45	**<.001**	−2.30	−2.55 – −2.04	**<.001**	0.83	0.67 – 1.00	**<.001**	−1.48	−1.71 – −1.26	**<.001**
Observations	134 678			134 678			134 678			134 678		
R^2 / R^2 adjusted	0.071 / 0.070			0.005 / 0.005			0.114 / 0.114			0.007 / 0.007		

sequentially, whereas simultaneous blood pressure measurement generally leads to lower IAD values.[14,15] Therefore, a systolic IAD as low as 5 mmHg may indicate additional cardiovascular risk, which rises with magnitude of the IAD.[6] Thus, measuring both arms could reveal clinically important information for about a third of people in this cohort.

Higher systolic IADs are strongly and consistently associated with presence of peripheral arterial disease and with cardiovascular risks and events.[5,6,35]

Despite the fact that most guidelines recommend the performance of double arm BP measurement little is known about the reproducibility of IAD on different occasions. Regarding the method used in the present study, Krogager and associates previously investigated IAD reproducibility using the same device by performing two successive sets of three individual measurements. The authors concluded that the method as was also used in the present study is acceptable for evaluating IAD of more than 10 mmHg and that an extra measurement session does little to improve detection of more than 10 mmHg.[33] Although this study suggests that IAD is reproducible, it must be considered that two measurement sessions were performed shortly after each other.

4.4 | Implications for clinical practice

International hypertension guidelines have recommended checking both arms as part of a BP assessment for more than 80 years.[36] However, this is not consistently undertaken in current practice. We found, in 2017, that 52% of UK practises reported measuring BP in both arms when considering a diagnosis of hypertension, but a quarter of GPs surveyed would not adopt the higher reading arm BP for diagnosis and management.[8] Meanwhile, in an online survey of 743 UK patients, only 88 (11.8%) recalled ever having their BP measured in both arms at any previous appointment, although this was more likely for those with hypertension (16.5%) than those without (6.7%).[9] Similarly, in the USA only 10% of first year and 31% of second to fourth year medical students checked BP in both arms during a clinical skill assessment.[37]

The mean systolic and diastolic IADs were close to zero, and too small to be clinically meaningful differences, with near equal proportions overall having a higher BP on the right or on the left arm. It has previously been suggested that higher BP in one arm might be related to hand-dominance and associated greater muscle mass in the upper-arm of the dominant arm. There is some evidence for abolition of previously observed mean differences in favor of the right arm being about 1 mmHg higher than the left when handedness is considered.[34,38] Anatomy of the cardiovascular system may also play a part and subclavian stenosis occurs more often on the left side than the right.[39–41] The explanation, in the absence of overt peripheral artery disease, is likely to be multifactorial. The current data reinforce the point that no clear prediction of which arm is higher can be made, therefore both arms need to be measured during assessment of BP. Failure to do so risks underdiagnosing and therefore under-treating arterial hypertension.

Like peripheral artery disease and cardiovascular disease, age is also a strong predictor of rising prevalence of IAD.[6,10,42,43] The present study showed a similar pattern with systolic and diastolic IADs ≥ 10 mmHg and ≥ 15 mmHg increasing with each decade in life.

Prevalence of smoking and dyslipidemia in this cohort was low (6.1% and .7% respectively), therefore we are cautious in interpreting the apparent inverse relationship of these variables with IAD in our models. We recently found a positive hazard for smoking in our individual participant data modeling of all-cause mortality taking account of IAD, although total cholesterol appeared to have a negative relationship.[6,43]

The presence of AF is associated with peripheral artery disease.[44] A systolic IAD ≥ 15 mmHg has previously been labelled subclavian stenosis, and it indicates a 2.5 times risk of presence of peripheral artery disease in comparison with lower IADs.[5,45] In this study, the presence of a monitor generated AF alert was significantly and independently associated with a higher IAD value. In addition, a more than 2 times greater chance of an AF alert was observed with an IAD ≥ 15 mmHg than with an IAD < 5 mmHg. One might think that the higher IAD values in patients with a monitor generated AF alert were caused by difficulties related to BP measurement in AF in general and, especially when using an oscillometric BP device.[46] However, it may be reasonably expected that this effect was minimal for this study because the BP monitor used is designed to accurately measure BP in AF patients[22] and IAD values were averaged from three BP readings. Finally, the presence of AF is related to higher BP variability which may explain the higher IAD values in patients with AF.[47]

AF was not confirmed following alerts in this study, however the implications of an IAD for checking further for vascular disease are supported by our findings.

5 | CONCLUSION

The current paper presents the largest clinical study performed thus far to investigate IAD using a simultaneous BP measurement method. More than 8% of all persons have a significant systolic IAD ≥ 10 mmHg and more than 2% of all patients have a significant systolic IAD ≥15 mmHg. This may indicate increased cardiovascular risk and, therefore justifies further clinical investigation. The prevalence of IAD increases with age. Large IADs are associated with a higher frequency of device generated AF alerts, independent of BP. Double-arm BP measurement should be undertaken during, at least, initial BP assessment. In the present study, almost 12% of all patients who were normotensive in one arm were hypertensive in the other, so up to 6% may be classified as normotensive if both arms are not taken into account during assessment for hypertension. Overall, the right arm showed slightly higher BP than the left. However, within the group having a systolic IAD ≥ 15 mmHg, over 50% of the persons had higher left-arm BP. As this systolic IAD ≥15 mmHg group consisted of a quarter of normotensive persons, more research is needed to investigate the reproducibility of this outcome and/or the cardiovascular risk of these persons.

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CONFLICTS OF INTEREST

CEC has previously received a Microlife Watch BP Office from Microlife for unrestricted evaluation outside of the current study. He has received honoraria from Bayer AG (for unrelated work) and ReCor Medical. No company has had, or will have, any involvement in the design, conduct, or reporting of this study.

WJV is an employee of Microlife corporation

NG is an employee of Eris Lifesciences

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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