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ORIGINAL ARTICLE

Should the first blood pressure reading be discarded?

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We evaluated the consequences of excluding the first of three blood pressure (BP) readings in different settings: a random population sample (POS, $n = 1525$), a general practice office (GPO, $n = 942$) and a specialized hypertension center (SHC, $n = 462$). Differences between systolic and diastolic BP (SBP and DBP) estimates obtained including and excluding the first reading were compared and their correlation with ambulatory BP monitoring (ABPM) was estimated. The samples were divided into quartiles according to the difference between the third and the first SBP (3-1ΔSBP). SBP decreased through sequential readings, 3-1ΔSBP was -5.5 ± 9.7 mm Hg ($P < 0.001$), -5.1 ± 10.4 mm Hg ($P < 0.001$) and -6.1 ± 9.3 mm Hg ($P < 0.001$) for POS, GPO and SHC, respectively. However, individuals included in the top quartile of 3-1ΔSBP showed their highest values on the third reading. The mean SBP estimate was significantly higher excluding the first reading ($P < 0.001$), but the differences among both approaches were small (1.5–1.6 mm Hg). Moreover, the correlation between SBP values including and excluding the first reading and daytime ABPM were comparable ($r = 0.69$ and 0.68, respectively). Similar results were observed for DBP. In conclusion, our study does not support the notion of discarding the first BP measurement and suggests that it should be measured repeatedly, regardless the first value.

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INTRODUCTION

Accurate office blood pressure (BP) measurement remains the mainstay of the diagnosis and treatment of hypertension, and the BP estimate in the first visit is the cornerstone of the initial management of hypertension as these values will be used to decide if subsequent visits are necessary. The recognition of a reduction in the white-coat effect through successive measurements of BP[1] has led to the suggestion that discarding the first office reading of a set of three may improve the possibility of knowing the actual BP. If BP always decreases in the subsequent measurements, additional BP readings are not necessary when the first measurement is $< 140/90$ mm Hg. However, the assumption that the first BP reading is systematically higher in all subjects was not widely studied. Two guidelines aimed at improving hypertension diagnosis and treatment in the clinical practice were recently published, the '2013 European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC) guidelines for the management of arterial hypertension'[2] and the '2013 Canadian Hypertension Education Program (CHEP) Recommendations for Blood Pressure Measurement, Diagnosis, Assessment of Risk, Prevention, and Treatment of Hypertension'.[3] They agree on a value of $\geqslant 140/90$ mm Hg as hypertension threshold, but there is disagreement regarding whether the first reading should be discarded or not. The ESH/ESC guidelines recommend taking 'at least two BP measurements, in the sitting position, spaced 1–2 min apart, and additional measurements if the first two are quite different'. On the other hand, the Canadian guidelines suggested that 'At the initial visit for the assessment of hypertension, if systolic BP is $\geqslant 140$ and/or diastolic BP is $\geqslant 90$ mm Hg, more than 2 additional readings should be taken during the same visit' and 'The first reading should be discarded and the latter 2 readings averaged'.

Disagreement about whether to discard the first BP measurement or not was also observed in population studies; for example, two recently published studies aimed at evaluating the variability of BP in the general population—both based on National Health and Nutrition Examination Survey (NHANES) data—estimated the BP using different criteria: the first used the average of the second and third measurement[4] whereas the other used the average of the three readings.[5]

The aim of our study was to evaluate the effect of discarding the first BP measurement. For this purpose the BP estimates including and excluding the first reading were compared in three different settings: (a) a random population sample, (b) a screening for high BP in general practice offices (GPOs) and (c) a specialized evaluation in a hypertension center. In the last setting we also evaluated whether discarding the first BP reading improves the relationship between office BP and ambulatory BP monitoring (ABPM) as was previously suggested.

MATERIALS AND METHODS

The study was performed using data from individuals who had had at least three consecutive BP readings on one occasion from three independent samples, (1) a random population sample, (2) consecutive patients in a GPO and (3) consecutive patients in a specialized hypertension center (SHC).

The methodology used in the random population sample to obtain measurements has already been published.[6,7] In brief, three BP measurements spaced around 2 min from one another were performed at home by trained nurses, after a minimum resting period of 5 min, using a mercury sphygmomanometer. Phase I and V Korotkoff sounds were used to identify systolic BP (SBP) and diastolic BP (DBP) respectively.

In the GPOs, doctors using the OMRON HEM 705 CP devices (OMRON HEALTHCARE Co., Kyoto, Japan) took three BP measurements separated by a minute in a single visit from every patient examined regardless of the purpose of the visit.

In the SHC specially trained nurses performed three BP measurements just before the realization of ABPM with the same device and methodology used in the GPO setting. The ABPM registries were performed with the SpaceLabs 90207 monitor (Spacelabs Healthcare, Issaquah, WA, USA) programmed to read BP at intervals of 20 min during the day and 30 min

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Table 1. Characteristics of the three samples, random population, general practice office and specialized hypertension office

	Random population (n *1525)*	*General practice* (n *942)*	*Specialized hypertension office* (n *462)*	*Total* (n *2929)*
Age (years), mean (s.d.)	45 (17)	46 (17)	51 (15)	46 (17)
Women (%)	63.5	56.2	61.3	60.8
BMI (kg m^{-2}), mean (s.d.)	25.8 (5.2)	27.7 (5.8)	30.2 (6.3)	27.1 (5.8)
Antihypertensive drugs (%)	12.8	22.5	55.0	22.6
Smoking (%)	24.8	26.3	14.3	23.6

Abbreviation: BMI, body mass index.

Table 2. First, second and third SBP readings and SBP estimates using mean of three BP readings and discarding the first measurement

Source	*Antihypertensive drugs*	*Systolic blood pressure readings*					P-*value*[a]
		SBP1	*SBP2*	*SBP3*	*Discarding first reading*	*Mean of three reading*	
		Mean (s.d.)	*Mean (s.d.)*	*Mean (s.d.)*	*Mean (s.d.)*	*Mean (s.d.)*	
Population sample	Without (*n* 1330)	137.5 (19.5)	133.7 (18.9)	132.2 (18.3)	133.0 (18.3)	134.5 (18.3)	< 0.001
	With (*n* 195)	165.3 (23.2)	161.2 (21.6)	158.5 (21.7)	159.9 (21.3)	161.7 (21.4)	< 0.001
	Total (*n* 1525)	141.1 (22.1)	137.3 (21.3)	135.6 (20.7)	136.4 (20.7)	138.0 (20.8)	< 0.001
General practice office	Without (*n* 730)	136.9 (20.3)	133.5 (19.2)	132.0 (18.4)	132.7 (18.3)	134.1 (18.6)	< 0.001
	With (*n* 212)	151.6 (21.7)	146.1 (20.3)	146.1 (20.3)	146.1 (19.7)	148.0 (19.9)	< 0.001
	Total (*n* 942)	140.2 (21.5)	136.3 (20.2)	135.2 (19.7)	135.7 (19.4)	137.2 (19.7)	< 0.001
Specialized hypertension office	Without (*n* 208)	140.9 (19.3)	137.1 (17.2)	134.5 (16.1)	135.8 (16.3)	137.5 (16.8)	< 0.001
	With (*n* 254)	145.2 (22.7)	141.9 (22.3)	139.4 (22.0)	140.6 (21.9)	142.2 (21.8)	< 0.001
	Total (*n* 462)	143.2 (21.3)	139.8 (20.3)	137.2 (19.7)	138.5 (19.7)	140.1 (19.8)	< 0.001

Abbreviations: SBP1, SBP2 and SBP3, firsts, second and third systolic blood pressure readings, respectively. [a]*P* values for the differences between systolic blood pressure values obtained discarding the first measurement and averaging the three readings (one-sample *t*-test).

Table 3. First, second and third diastolic blood pressure readings and diastolic blood pressure estimates using mean of three BP readings and discarding the first measurement

Source	*Antihipertensive drugs*	*Diastolic blood pressure readings*					P-*value*[a]
		DBP1	*DBP2*	*DBP3*	*Discarding first reading*	*Mean of three reading*	
		Mean (s.d.)	*Mean (s.d.)*	*Mean (s.d.)*	*Mean (s.d.)*	*Mean (s.d.)*	
Population sample	Without (*n* 1330)	88.6 (14.2)	86.6 (13.7)	85.5 (13.5)	86.0 (13.1)	86.9 (13.0)	< 0.001
	With (*n* 195)	101.5 (14.7)	99.7 (14.6)	99.1 (15.5)	99.4 (14.4)	100.1 (13.9)	0.002
	Total (*n* 1525)	90.3 (14.9)	88.2 (14.5)	87.3 (14.5)	87.8 (14.0)	88.6 (13.8)	< 0.001
General practice office	Without (*n* 730)	81.2 (12.0)	80.0 (11.5)	79.1 (11.3)	79.5 (10.9)	80.1 (10.7)	< 0.001
	With (*n* 212)	85.7 (12.7)	85.6 (12.0)	85.2 (12.3)	85.4 (11.6)	85.5 (11.6)	0.552
	Total (*n* 942)	82.2 (12.3)	81.2 (11.9)	80.5 (11.8)	80.8 (11.3)	81.3 (11.2)	< 0.001
Specialized hypertension office	Without (*n* 208)	84.9 (11.9)	83.4 (11.2)	82.8 (11.4)	83.1 (11.1)	83.7 (11.1)	< 0.001
	With (*n* 254)	83.7 (13.4)	82.4 (12.6)	81.6 (13.2)	82.0 (12.7)	82.6 (12.7)	< 0.001
	Total (*n* 462)	84.2 (12.8)	82.9 (12.0)	82.1 (12.4)	82.5 (12.0)	83.1 (12.0)	< 0.001

Abbreviations: DBP1, DBP2 and DBP3, first, second and third diastolic blood pressure readings, respectively. [a]*P* values for the differences between diastolic blood pressure values obtained discarding the first measurement and averaging the three readings (one-sample *t*-test).

during the night. Day and night was differentiated by taking into account the patient's diary.

To analyze the BP behavior through successive readings and evaluate if the first reading was systematically highest, mean and quartiles of the difference between the third and first SBP (3-1ΔSBP) and DBP (3-1ΔDBP) readings were estimated. In order to determine the effects of antihypertensive drugs, individuals with and without treatment were analyzed separately. Age and body mass index were compared among quartiles of 3-1ΔSBP using analysis of variance with Tukey *post hoc* analysis, and sex and current smoking using χ^2-test.

To estimate the effect of discarding the first BP reading, mean BP was estimated in each subject using two different approaches: (1) discarding the first measurement and (2) averaging the three readings.

Differences between SBP and DBP values obtained using both approaches were calculated and compared using one-sample *t*-test. Also, for each sample, Bland–Altman plots were constructed with the difference of the two approaches on the vertical axis and the average of the two approaches on the horizontal axis. Horizontal reference lines on the scatterplot showed the difference between the measurements ± 2s.d.

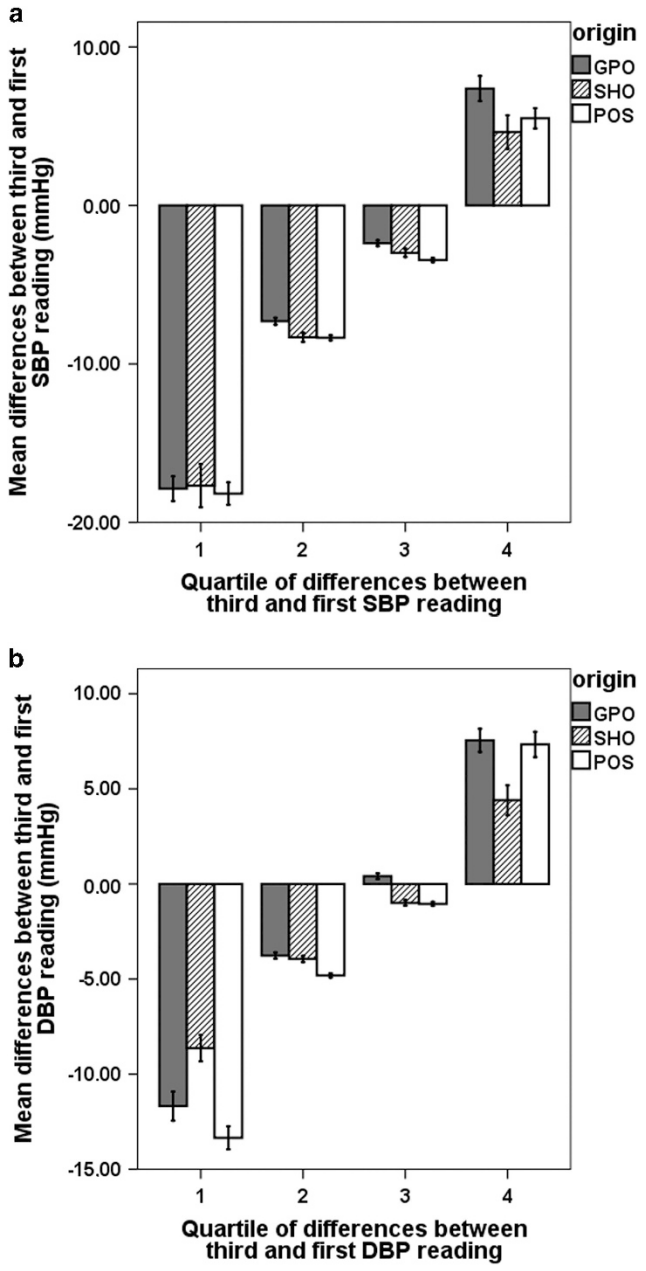

Figure 1. Mean differences between the third and the first SBP (**a**) and DBP (**b**) readings according to quartiles of these differences in the three samples analyzed: random population sample (POS), general practice office (GPO) and specialized hypertension office (SHO).

In order to investigate the concordance of high BP diagnosis (SBP⩾140 mm Hg and/or DBP⩾90 mm Hg) among both BP estimates, we calculated the kappa coefficient (κ) after dichotomizing the office measurements as 'high' or 'low' BP. The prevalence of high BP both including and excluding the first BP reading were compared using McNemar's test.

Finally, in the SHC sample, the relationship between the office BP values obtained and the mean daytime ABPM were evaluated using Pearson correlation coefficient (r); additionally, 95% confidence intervals (95%CI) for r values were calculated based on the Fisher r-to-z transformation.

Statistical analyses were performed using SPSS 18.0 software (SPSS, Chicago, IL, USA); two-tailed P-values <0.05 were considered statistically significant.

RESULTS

The study included 2926 individuals (1780 women, 46 ± 17 years old and 1149 men, 47 ± 17 years old, P between sex = 0.566). The characteristics of the three samples are described in Table 1.

As Tables 2 and 3 show, mean BP decreased across the sequential readings; the mean decrease was similar in all settings; Δ3-1SBP was −5.5 ± 9.7 mm Hg ($P<0.001$), −5.1 ± 10.4 mm Hg ($P<0.001$) and −6.1 ± 9.3 mm Hg ($P<0.001$) in the random population sample, GPO and SHC, respectively; Δ3-1DBP was −3.0 ± 9.0 mm Hg ($P<0.001$), −1.71 ± 7.8 mm Hg ($P<0.001$), and −2.1 ± 5.7 mm Hg ($P<0.001$) in the random population sample, GPO and SHC, respectively. However, when the samples were divided into quartiles of the Δ3-1SBP, the individuals included in the top quartile had higher SBP values in the third reading compared with the first one (Figure 1a); similar behavior was observed with DBP when it was divided into quartiles of Δ3-1DBP (Figure 1b). Individuals in the top quartile of Δ3-1SBP were younger (46 ± 18 vs 49 ± 16 years old, $P=0.007$) and thinner than individuals in the first quartile of (body mass index 26.7 ± 5.4 vs 28.1 ± 6.6, $P<0.001$). The percentage of current smokers was higher in the top quartile of Δ3-1DBP than in the remaining quartiles (26.4 vs 22.6, $P=0.034$). The percentage of women was similar among quartiles of Δ3-1SBP (61.2, 62.5, 61.6 and 58.0, $P=0.284$).

Tables 2 and 3 also compare the difference between the mean of all readings and the mean excluding the first reading; SBP and DBP were significantly lower in all settings when the first reading was discarded. Although the mean differences for SBP including and excluding the first BP reading seem only modest, 1.5 (3.0), 1.6 (2.8) and 1.6 (2.8) mm Hg for GPO, specialized hypertension and office random population sample, respectively (Table 2), the range was wide, and included positive and negative values (from −13.3 to 27.3 mm Hg) (Figure 2, Bland–Altman plots). Therefore, excluding the first reading did not yield lower values systematically. Similar results were obtained for DBP (Table 3); the mean differences between BP estimates were 0.5 (2.3), 0.6 (1.7) and 0.8 (2.6) mm Hg for GPO, specialized hypertension and office random population sample, respectively.

The proportion of individuals with 'high' BP (⩾140/90 mm Hg) was lower when the first reading was excluded in all settings (42.3% vs 44.6% in the random population sample, $P<0.001$, 42.3% vs 44.3% in the GPO, $P=0.005$ and 45.5% vs 48.7% in the SHC, $P=0.001$). However, the concordance between approaches was high ($\kappa=0.90$, 0.91 and 0.91 for the random population sample, the GPO and the SHC, respectively); indeed, 2794 of 2929 subjects were classified concordantly; among the 135 subjects classified discordantly, 75.6% were considered as 'high' BP only when the mean of all three readings was used and 24.4% when the first BP reading was excluded.

In the SHC sample, 446 ABPMs were considered valid. The correlations between daytime systolic ABPM and both approaches to estimate office SBP were modest but similar, $r=0.69$ (95% CI 0.64–0.73, $P<0.001$) and $r=0.68$ (95% CI 0.61–0.73, $P<0.001$), for the mean of three readings and excluding the first measurement, respectively (Figure 3). The correlations between daytime diastolic ABPM and office DBP estimates were also similar, $r=0.69$ (95% CI 0.64–0.73, $P<0.001$) and $r=0.68$ (95% CI 0.63–0.73, $P<0.001$), respectively.

DISCUSSION

Accurate office BP measurement, despite its shortcomings, remains the mainstay of diagnosis and treatment of hypertension. However, the simple question of whether the first office BP measurement should be discarded remains to be answered and there is no agreement among the varying hypertension guidelines. Thus, the Canadian[3] and NICE[8] guidelines recommend

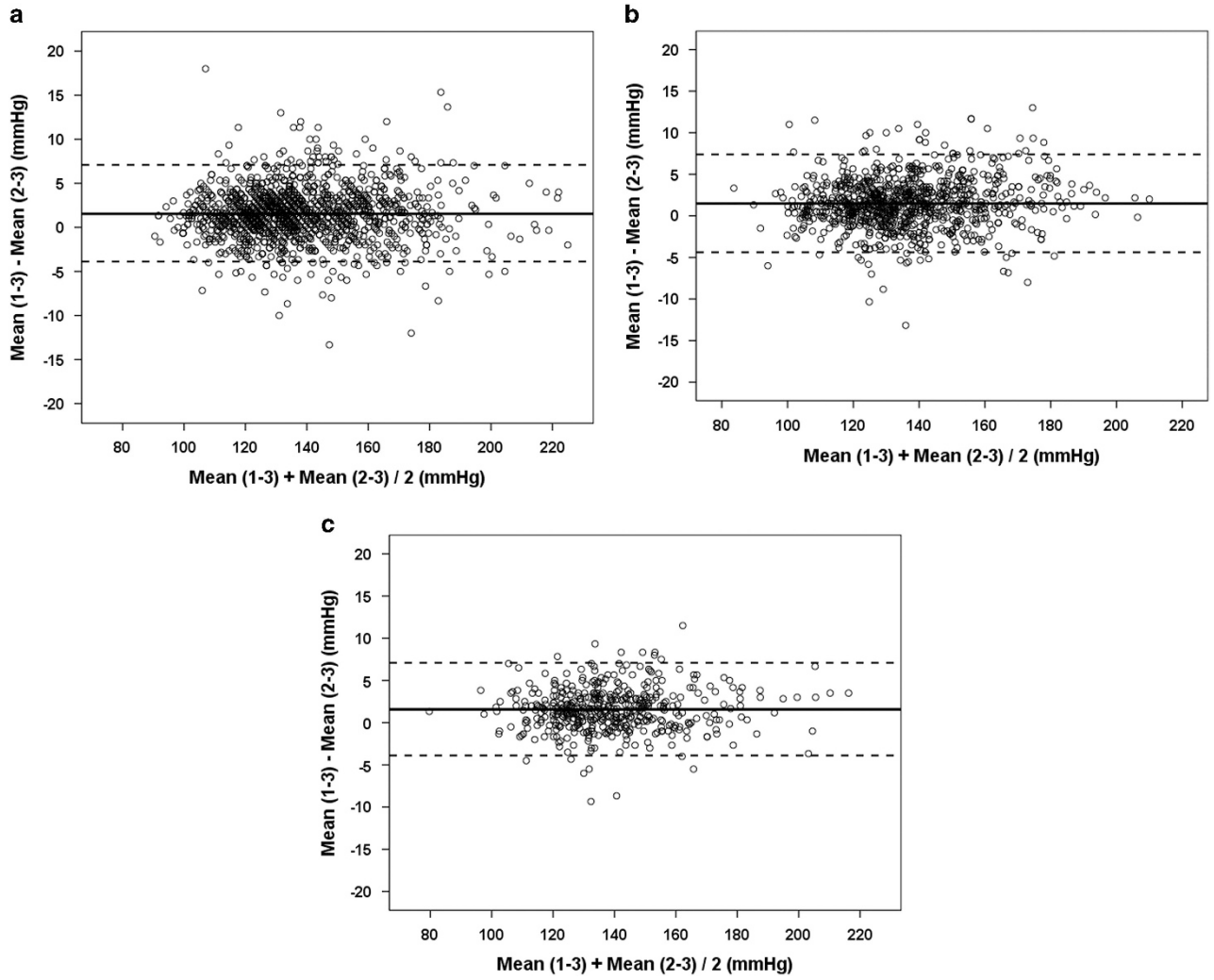

Figure 2. Bland–Altman plots comparing the SBP estimate using the mean of three readings and discarding the first reading in the three samples analyzed: random population sample (POS) (**a**), general practice office (GPO) (**b**) and specialized hypertension office (SHO) (**c**).

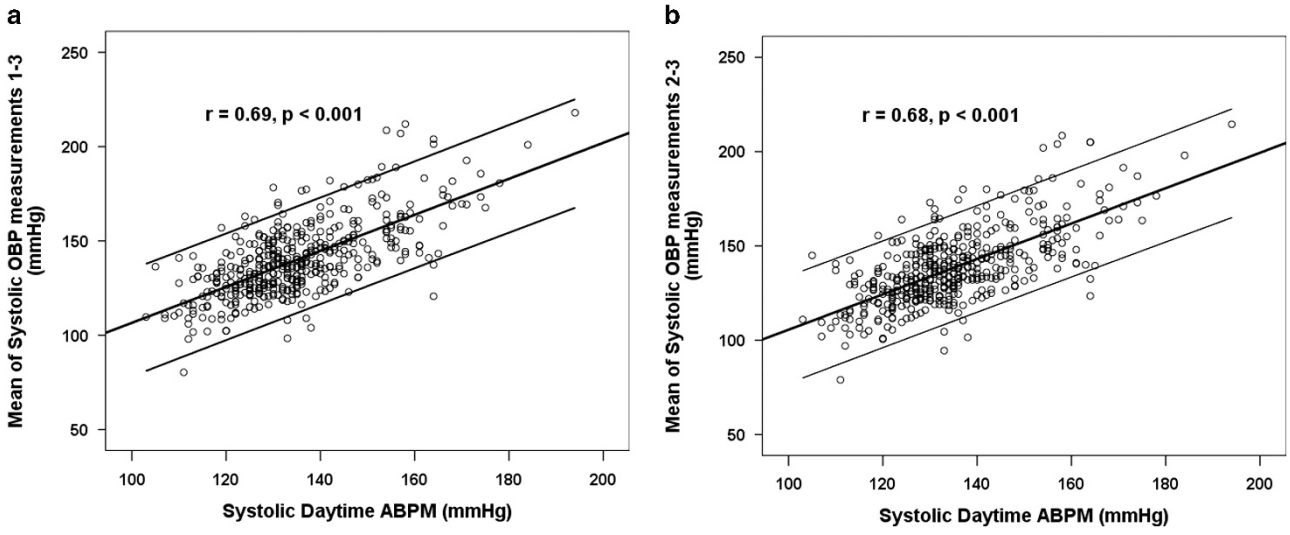

Figure 3. Pearson's correlation between systolic daytime ambulatory blood pressure monitoring (ABPM) and the office systolic blood pressure (OBP) estimate obtained using (**a**) the mean of three readings and (**b**) discarding the first reading.

discarding the first BP measurement, whereas the ESH/ESC one does not.[2] Our data show that, in all settings analyzed, the effect of excluding the first BP reading was significant but modest, ~1.5 and <1 mm Hg for SBP and DBP, respectively. Moreover, when BP was analyzed as a dichotomic variable in order to classify subjects as 'high' or 'low' BP, the vast majority were classified concordantly.

It has been suggested that excluding the first BP measurement could improve the correlation between office BP and out of the office BP. However, our data do not support this concept; using the second and third readings only (that is, discarding the first) did not improve the correlation with daytime ABPM when compared with the use of mean of all three readings; indeed, *r* values were almost identical whether the first BP measurement was included or not. This statement is concordant with a previously published study about untreated hypertensive patients[9] but expands the conclusion to non-hypertensive subjects and to subjects using antihypertensive drugs.

The decrease of BP in successive measurements has been shown repeatedly and with different methods,[10] and it is widely internalized in medical thinking that successive measurements will give lower BP values. Thus, Parati *et al.*[4] suggested that discarding the first reading may improve the accuracy of the diagnosis of hypertension. Furthermore, in order to eliminate the increase of BP associated with the effect of alarm, ESH guidelines for home BP measurement recommend discarding the measurements performed on the first day.[11] However, the scientific evidence to support these assumptions is minimal and valuable information about BP variability could be lost.

Perhaps the most interesting finding in our study was the fact that ~25% of the individuals did not decrease or increase their BP trough successive measurements and, consequently, in these individuals the first reading was not the highest. Remarkably, this behavior was found in all three settings (population sample, general practice and specialized hypertension office) and it was also independent of whether BP was measured by medical doctors or nurses, in the office or at home. Despite this phenomenon being previously published,[12] it is not widely recognized and it has several implications for clinical practice.

First, the consequences of excluding the initial reading are unpredictable for an individual patient. As Bland–Altman plots show, the differences among BP estimate excluding or including the first measurement were wide, and yield both positive and negative values. Indeed, although the individuals who increased their BP in the third reading were younger, thinner and more current smokers than those who decreased BP trough successive measurements (first quartile of 3-1ΔSBP), there are no practical ways to identify them. Interestingly, the reclassification of individuals in categories of BP using the mean of the first and second, first through third, and second and third readings was recently published.[13]

Another related issue is whether or not a doctor should take more readings only when the first is $\geqslant$140/90 mm Hg as the NICE guidelines and Canadian recommendations suggest; our findings do not support this approach. As the cardiovascular risk has a continuous relationship with BP starting with values as low as 115/75 mm Hg,[14] taking only one BP measurement could significantly underestimate the subject's 'true' risk of cardiovascular event.

Finally, the difference between the first and third reading could give some important information about the BP variability. There is now some evidence that several such representations of BP variability, if augmented, increase cardiovascular risk independent of the average of BP readings conventionally acquired.[15] Visit-to-visit SBP variation was linked to increased cardiovascular and stroke mortality risk.[16] Although the risk associated with the short-term variability has been studied less, the BP variation in one visit results from changes in heart rate, stroke volume and peripheral resistance in response to external and internal stimuli and their importance in terms of the risk of developing hypertension or cardiovascular disease remain to be defined.

Some limitations of our study have to be pointed out. First, this was a *post hoc* analysis. Second, this study was performed in different settings with different methodologies to measure BP. However, our findings were concordant through all the samples, suggesting that the BP patterns observed were strongly consistent. Finally, our study was not able to define whether one approach would be more appropriate than another; only long-term prospective studies with hard end points could provide a definitive answer.

In conclusion, our study does not support discarding the first BP measurement as the Canadian and NICE guidelines have suggested. Remarkably, although the mean BP decreased in successive BP readings, the behavior of individuals was unpredictable and an appreciable proportion of subjects had the highest BP value in the last reading. We suggest that three BP readings should be taken in all individuals independently of the first reading value.

What is known about this topic

- The office blood pressure is the cornerstone in the initial management of hypertension.
- The recently published ESH/ESC and Canadian guidelines for the management of arterial hypertension disagree on whether the first reading should be discarded or not.
- Recognition of the office pressure effect has led to the suggestion that discarding the first office reading may improve the possibility of knowing the actual blood pressure.

What this study adds

- Our study does not support discarding the first BP measurement.
- While the mean blood pressure decreased trough successive measurements, the third reading was higher than the first in almost a quarter of the subjects.
- Consequently, blood pressure should be measured repeatedly regardless of the first reading value.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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