Office blood pressure variability in non-hypertensive patients during a preventive examination

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Abstract

Background: Despite advantages of ambulatory and home blood pressure monitoring, office blood pressure measurement remains the principal method for the diagnosis and management of hypertension. There still seems to be too little evidence to date showing variation in blood pressure during a medical visit and the current recommendations are mainly based on expert's opinions. The aim of this study was to evaluate the difference between the first two blood pressure measurements performed during a preventive examination and to verify whether the second measurement could influence clinical decisions in non-hypertensive patients.

Material and methods: The study included 52 consecutive patients without history of hypertension or other cardiovascular diseases. Blood pressure and heart rate (HR) were measured twice, the first reading after 5 minutes rest and the second 1 minute later.

Results: Significant differences were found between the first (fBPM) and second (sBPM) blood pressure measurements, both systolic blood pressure (SBP) 142.4 mm Hg [interquartile range (IQR): 130.8–152.0] *vs.* 138.1 mm Hg (IQR: 125.8–149.5), $p < 0.001$ and diastolic blood pressure (DBP) 85.8 mm Hg (IQR: 80.0–91.5) *vs.* 83.9 mm Hg (IQR: 77.0–90.3), $p < 0.001$, and heart rate (HR) 73.1/min (IQR: 64.8–80.0) *vs.* 71.8/min (IQR: 64.8–77.3), $p < 0.001$. In 63.5% of the participants, the difference between the measurements was over 5 mm Hg for SBP values and in 23.1% of the participants for DBP values. According to fBPM, 53.8% of the patients met the criteria for the diagnosis of hypertension and according to sBPM 48.1% (NS).

Conclusion: We demonstrated substantial discrepancies between blood pressure values taken during the first and the second preventive medical check-up visit performed in the workplace. Preventive examination in the workspace is associated with similar number of false-positive results when hypertension status is evaluated as compared to regular office visits.

Key words: blood pressure measurement; hypertension; preventive examination

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Introduction

Despite undeniable advantages of ambulatory blood pressure monitoring (ABPM) and home blood pressure monitoring (HBPM) methods, office blood pressure measurement (OBPM) remains the principal method for the diagnosis and management of hypertension (HT) [1, 2]. Most often, sus-

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picion of HT appears after a routine blood pressure (BP) measurement in a General Practitioner office or during a preventive examination. Therefore, it is very important to keep the appropriate standards for such measurement.

The current guidelines determine different standards for OBPM, including the number of measurements. The European Society of Hypertension (ESH) recommends three measurements or more if the difference between the first and second reading is greater than 10 mm Hg [1]. According to A Report of the American College of Cardiology/American Heart Association (AHA/ACC) Task Force on Clinical Practice Guidelines the average of two or more measurements should be used [2]. Canadian Hypertension Education Program (CHEP) recommendations include discarding the first reading and averaging the latter two [3]. The National Institute for Health and Care Excellence (NICE) guidelines recommend a second measurement during the consultation only if BP measured is 140/90 mm Hg or higher [4]. It should be emphasized that these recommendations are based on anecdotal beliefs and expert's statements and opinions [5]. Surprisingly, there have been no valuable studies before the mentioned recommendations were made, that would show the differences in blood pressure values between consecutive measurements. In recent years only a few studies attempted to validate multiple blood pressure measurements [6–10]. There still seems to be too little evidence to date showing significant variation in blood pressure over a short period of time during a medical visit. This especially applies to healthy individuals without diagnosed HT during periodic occupational medical examinations or preventive examinations, when standards are not used very often [11, 12].

The aim of this study was to evaluate the difference between the first two OBPM measurements and to verify whether the second measurement could influence clinical decisions in people with no history of HT.

Material and methods

Participants

The study initially involved 70 consecutive patients who underwent preventive examination in their workplace. Subsequently, after taking medical history, patients with known HT or other cardiovascular diseases were excluded from the study. Finally, results of 52 subjects free of known chronic disease were analyzed.

Blood pressure measurement

BP was measured twice during the workplace prophylactic examination. BP and heart rate (HR) were recorded by an automatic device (OMRON Basic M2) with an upper arm cuff with circumference from 22 to 42 cm. The first reading was taken after 5 minutes rest and the second reading 1 minute later. The arm on which the measurement was performed was selected at random. During the measurements, participants were sitting with their backs supported, arms exposed and propped, the center of the cuff was placed at the level of the heart, and the lower edge of the cuff 3 cm above the elbow fold. All BP measurements results are presented in mm of Hg.

In addition, height and weight were measured and body mass index (BMI; kg/m^2) was calculated as the weight (kg) divided by the height^2 (m^2).

All results were evaluated for normality of distributions with the Shapiro-Wilk test. Systolic and diastolic blood pressure values were compared by Student's t-test and heart rate by Wilcoxon's test. The significance level was assumed to be $p < 0.05$. The Pearson correlation coefficient was used to evaluate the relationship between blood pressure and heart rate differences and height, weight, and BMI.

Statistical calculations were performed using the R package (version 4.0.3), R-core Team, R Foundation for Statistical Computing, Vienna, Austria, https://www.r-project.org.

The Bioethics Committee at the Medical University of Warsaw issued a statement on 18 January 2021, number AKBE/13/2021, and approved the study.

Results

Fifty two patients without a history of HT, including 26 women, were enrolled in the study. The median age was 54 years [interquartile range (IQR): 38–59], mean height 1.70 m (IQR 1.64–1.76), weight 77.46 kg (IQR 67.25–83.75) and BMI 26.51 kg/m^2 (IQR 23.00–29.31). The size of the study group was predetermined by the power test calculation using the OpenEpi software based on studies with similar study group size. Significant differences were found between the first and second measurements, both systolic (SBP) and diastolic (DBP) blood pressure and heart rate (HR). The mean difference in SBP was –4.3 mm Hg (SD 5.9), DBP –1.9 mm Hg (SD 3.1) and HR –1.3/min (SD 2.0). The mean of the two readings also differed significantly from the first measurement (Tab. 1). For over 60% of the participants, the difference between the measure-

Table 1. The differences between consecutive blood pressure (BP) and heart rate (HR) measurements

	fBPM (IQR)	sBPM (IQR)	mBPM (IQR)
SBP [mm Hg]	142.4 (130.8–152.0)	138.1a (125.8–149.5)	140.2a (128.5–150.5)
DBP [mm Hg]	85.8 (80.0–91.5)	83.9a (77.0–90.3)	84.9a (77.9–91.3)
HR [bpm]	73.1 (64.8–80.0)	71.8a (64.8–77.3)	72.4a (64.6–79.0)

SBP — systolic blood pressure; DBP — diastolic blood pressure; HR — heart rate; fBPM — first measurement of blood pressure; sBPM — second measurement of blood pressure; mBPM — mean of two blood pressure measurements; IQR — interquartile range; [a]$p < 0.001$ — as compared to fBPM

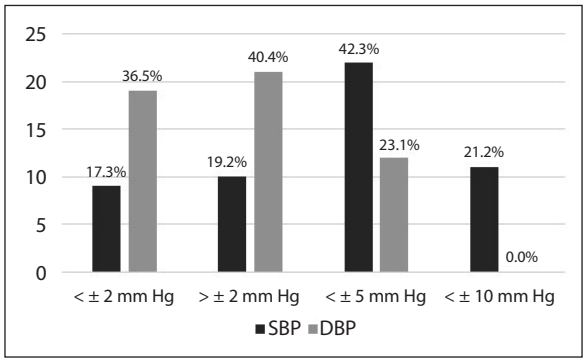

Figure 1. The percentage of the participants with different blood pressure changes between the first and second measurements. SBP — systolic blood pressure; DBP — diastolic blood pressure

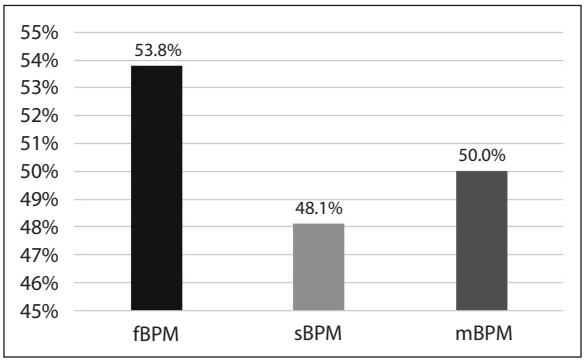

Figure 2. Meeting the criteria for the diagnosis of hypertension depending on the measurement. fBPM — first measurement of blood pressure; sBPM — second measurement of blood pressure; mBPM — mean of the two blood pressure measurements

ments was over 5 mm Hg of SBP and for over 20% also of DBP (Fig. 1). According to the diagnostic criteria of HT in most major recommendations, i.e., 140 mm Hg for SBP or 90 mm Hg for DBP, 53.8% (n = 28) of the subjects met the criteria for the diagnosis of HT after the first blood pressure measurement (fBPM). Based on the second measurement (sBPM), 25 people would have been diagnosed with HT, and on the average of the two measurements (mBPM) – 26 people. However, the differences were not statistically significant (Fig. 2). The difference in DBP correlated positively with weight ($r = 0.29$, $p < 0.05$), and the difference in HR correlated with BMI ($r = 0.33$, $p < 0.05$) and weight ($r = 0.30$, $p < 0.05$) (Fig. 3). However, no other statistically significant correlation was found between the variability of SBP, DBP and HR with weight, height and BMI.

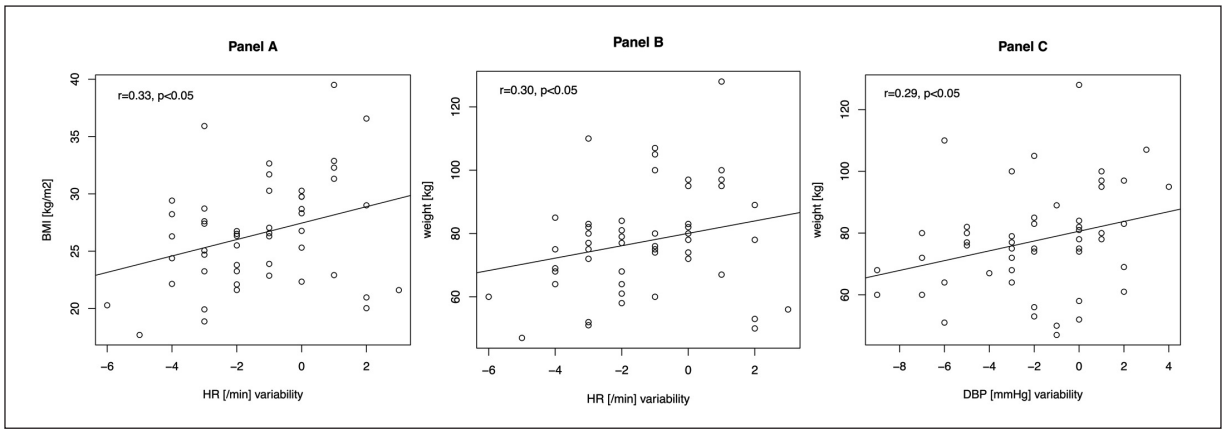

Figure 3. Correlations between heart rate variability and body mass index (BMI) (**A**), heart rate (HR) variability and weight (**B**) and diastolic blood pressure (DBP) variability with weight (**C**)

Discussion

Multiple blood pressure measurements during a single office visit are essential for a diagnostic process according to almost all guidelines [1–3]. The NICE guidelines are the only ones that recommend a single measurement, but only when the first reading is less than 140/90 mm Hg [4]. Following these standards in everyday practice is a well-known problem and many doctors base their decisions on inaccurate measurements. This mainly applies to not waiting for a 5 minutes rest before taking a measurement, and even half of the physicians take only one measurement [11, 12]. Our study did not meet the criteria of a medical visit, but a screening test. Due to a high percentage of patients unaware of the presence of HT (18–50%) [13–17], any possibility of measuring blood pressure is valuable. OBPM remains the standard for the diagnosis of HT according to most guidelines, especially in screening. Some of them recommend [1, 2] and some require confirmation by ABPM or HBPM [3, 4], primarily to exclude white coat hypertension (WCH). However, due to high costs and availability, ABPM is often not possible to perform, and not every patient has a device for self-measurement of blood pressure before HT is diagnosed.

One of our main findings is that there are significant differences in the results of the fBPM and sBPM during one preventive examination. It is worth noting that blood pressure variability and the number of measurements recommended in the current guidelines are not scientifically substantiated especially during preventive examinations. Only a few studies have compared the fBPM with the subsequent ones. Among 802 subjects, Burkard et al. showed a significant difference between fBPM and the mean of the three subsequent measurements (mBPM) (129/80 mm Hg *vs.* 123/79 mm Hg, $p < 0.001$) [6]. More than a half of the patients in this study had a difference of more than 5 mm Hg SBP between fBPM and mBPM, and almost one third in DBP. Surprisingly, our study showed a similar percentage, but already between fBPM and sBPM, above 60% and 20% of patients, respectively. The difference of ± 5 mm Hg in OBPM, depending on the measurement method used, may influence a decision-making when diagnosing and initiating the treatment for HT. It becomes even more important when we take into account that a reduction in SBP by 2 mm Hg translates into a reduction in the risk of mortality due to stroke by 10% and due to coronary artery disease (CAD) by 7% [18], and a reduction in SBP by 10 mm Hg reduces the relative risk of major cardiovascular events by 20% [19]. According to Burkard et al.'s analysis, 34.2% of participants met the HT criteria after fBPM, and only 22.4% met the HT criteria according to mBPM. In our study, we found a greater percentage of patients meeting the criteria, 53.8% after fBPM, 48.1% after sBPM and after calculating mBPM — 50%. It should be emphasized, however, that in the cited study 32.5% of patients had already been diagnosed with and treated for HT, 11% CAD, 11% diabetes and 5% heart failure. A large Australian study, based on the data from the Australian Health Survey, analyzed the results of two (n = 20,716) or three consecutive measurements (n = 5,189) and their variability by HT classification and age [7]. However, the authors did not compare the first BP and second BP values directly but only showed the overall mean difference in SBP of 1.67 mm Hg. A change between first SBP (fSBP) and second SBP (sSBP) equal or greater than 5 mm Hg was found in 51% of the subjects. According to the European Society of Hypertension/European Society of Cardiology (ESH/ESC) guidelines, sSBP allowed to reclassify HT in 3% of young people (age < 50) and in 1% of the elderly (age > 50), but after the third SBP (tSBP) this percentage increased to 16% and 9%, respectively. In this study the prevalence of HT was 10.2%, diabetes mellitus 4.6% and heart diseases 5%. The authors emphasized the strong influence of age on fSBP and the difference between the first and second measurements that decreased with increasing age. The National Family Health Survey (NFHS-4), a country-wide study conducted in India in 2015–2016, showed lower average value of the 2nd and 3rd SBP and DBP than the 1st measurement of 3.6 mm Hg and 2.4 mm Hg, respectively [8]. These differences resulted in the reclassification of approximately one third of patients with grade 1 hypertension to high normal or normal blood pressure. Another interesting result was obtained by Lu et al. who compared three BP measurements among patients without diagnosed HT (n = 8905) [9]. Compared to the reference BP result for this study (the average of 2nd and 3rd measurements), the 2nd measurement characterized less misclassifications than the 1st and the mean of 1st and 2nd. The percentage of patients with overdiagnosed HT was 6.4% *vs.* 18.3% *vs.* 13.7% and with missed HT 2.1% *vs.* 2.8% *vs.* 1.3%, respectively. It is worth noting that the 2nd measurement, contrary to our results, was higher than the 1st one (116.1 mm Hg *vs.* 115.8 mm Hg), which lead to more overdiagnosed than missed cases of HT. The National Health

and Nutrition Examination Survey (NHANES), which represents a large database (n = 22,633) of multiple blood pressure measurements, showed that based on the 1st BPM, 18.2% of stage 1 hypertensive patients and 33.5% of stage 2 hypertensive subjects were reclassified to lower BP categories and only rarely (< 0.2%) were they reclassified from non-hypertensive to stage 1 HT [10]. The authors concluded that patients with initial BP above normal especially require additional measurements.

Short-term changes in blood pressure under resting conditions result from a combination of homeostatic mechanisms [20]. The dominant one is sympathetic nerve activity (SNA), effectiveness of which decreases with age due to decreased alpha-adrenergic sensitivity and decreased release of norepinephrine [21, 22]. Our study did not show such a correlation. We revealed not strong but significant correlation between the difference in DBP with body weight and HR with body weight and BMI. SNA is higher in overweight and obese patients [23], which may explain the above phenomenon. Greater blood pressure variability was observed in obese and overweight patients during ABPM [24] and in OBPM between two separate visits [25]. Therefore, this group of patients may require more measurements during one visit and /confirmation of BP values in ABPM or HBPM.

In almost every study mentioned, as well as in ours, the consecutive measurements were lower than the first one, which refers also to individuals without any history of chronic disease. Incorrectly performed measurements may result in overdiagnosis and unnecessary initiation of treatment for HT, but may also cause patients' feeling of sickness, stress, and may also restrict access to certain medical services.

Study limitations

Due to the limitations of the preventive examination, not every recommendation of the ESC/ESH guidelines could be applied in this study. Time pressure, which is common for both, a standard medical visit and preventive examination, did not allow for the measurements in both arms. Also, due to the lack of appropriate conditions, the arm circumference was not measured, and a universal upper arm cuff with circumference from 22 to 42 cm was used. We would like to emphasize that the assumption of the study was to check the variability of OBP values obtained rather in real life than in "clinical trials" conditions.

Conclusion

We demonstrated substantial discrepancies between blood pressure values taken during the first and the second preventive medical check-up visit performed in the workplace. Preventive examination in the workspace is associated with similar number of false-positive results when hypertension status is evaluated as compared to regular office visits.

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