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Evaluation of blood pressure through home monitoring in brazilian primary care: a feasibility study

Avaliação da pressão arterial através da monitorização residencial na atenção básica brasileira: um estudo de viabilidade

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Abstract *Blood pressure measurements taken in a clinical setting are subject to errors, therefore there are advantages to monitoring blood pressure at home, especially in in patients diagnosed with hypertension. The study describes the feasibility of home monitoring to assess blood pressure in primary care and compares blood pressure measured at home and during a medical consultation. This cross-sectional study was carried out with patients whose used home blood pressure in the morning and evening, thrice for seven consecutive day sat home. Participants included patients older than 18 years with suspected whitecoat hypertension, taking antihypertensives, or those intolerant of ambulatory blood pressure monitoring, and excluded patients who did not follow the protocol, suffered from an irregular heart rate, and pregnant women. Of the 134 patients who participated in the study, 63.3% had altered blood pressure when measured at health facilities and 48% had higher blood pressure at home. The mean difference between the methods was 10.1 mmHg for systolic and 4.3 mmHg for diastolic. The prevalence of whitecoat hypertension was 19.4%. Blood pressure monitoring at home is a practicable strategy in the Brazilian healthcare system.*

Key words *Home blood pressure monitoring, Blood pressure, Hypertension*

Resumo *A medição da pressão arterial no consultório está sujeita a erros; assim, a monitorização residencial da pressão arterial é utilizada para o monitoramento e diagnóstico da hipertensão. Descrever a viabilidade da monitorização residencial para avaliar a pressão arterial na atenção primária e comparar os valores da pressão arterial através da monitorização residencial e medida de consultório. Estudo transversal realizado com pacientes que utilizaram a monitorização residencial pela manhã e pela noite, em triplicata por sete dias consecutivos em domicílio. Foram incluídos pacientes maiores de 18 anos, com suspeita de hipertensão do avental branco, utilizando anti-hipertensivos ou intolerantes a monitorização ambulatorial. Foram excluídos pacientes que não seguiram o protocolo, aqueles que apresentavam ritmo cardíaco irregular ou mulheres grávidas. 134 pacientes participaram do estudo, 63,3% apresentaram pressão arterial alteradas em consultório e 48% pela monitorização residencial. A diferença média dos métodos foi de 10,1 mmHg para sistólica e 4,3 mmHg para diastólica. A prevalência de hipertensão do avental branco foi 19,4%. A monitorização residencial da pressão arterial no sistema de saúde brasileiro provou ser uma estratégia viável.*

Palavras-chave *Monitorização ambulatorial da pressão arterial, Pressão arterial, Hipertensão*

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Introduction

Blood pressure (BP) measurement is the basis for the diagnosis, treatment, and management of systemic arterial hypertension and all decisions related to this pathology will be influenced by the accuracy of BP measurement[1]. Several factors including environmental conditions, emotional state, methodology, presence of comorbidities such as diabetes, and the device used are directly associated with variations in BP measurement that should be controlled to minimise errors[1,2]. Multiple automated measurements without the presence of a physician or nurse correlate more strongly with accurate BP measurements, compared to those obtained within a health facility[3-5]. Especially in primary care, the simple office measurement is subject to several factors that can lead to errors and a reduced number of readings may show poor reproducibility in the long term, and, consequently, lead to unnecessary treatment[6-8].

Ambulatory blood pressure monitoring (ABPM) is the gold standard for the diagnosis of hypertension; however, it has low availability in Brazilian primary care services. It requires doctors with specialist knowledge and is at a high cost for public health services[9]. Parallel to this, home blood pressure monitoring (HBPM) is a strategy that is used in several countries for the monitoring of hypertension, in order to improve therapeutic adherence, awareness of the disease in the hypertensive patient and diagnosis of hypertension and its variations[10]. HBPM differs from the self-measurement of BP because is accompanied by protocols to carry out the measurements[11], and is similar to ABPM for the diagnosis and monitoring of patients with hypertension, white coat hypertension (WCH) and Masked Hypertension[12]. Also, the request and interpretation of the result can be performed by any qualified professional in the health care team, which facilitates assessment in underserved areas. Compared to measurements taken in a clinical setting, HBPM improved BP control during treatment, patients had no stress reaction to BP, it increased the possibility of digital storage and telemonitoring, and it was better at predicting clinical outcomes because patients could take BP measurements repeatedly over several days, which allowed for greater reliability in the results[2,10].

In Brazil, HBPM is not a procedure included in the public health system. It is assumed that the use of HBPM can improve the management and diagnosis of hypertension according to accepted procedures recommended by clinical guidelines. This study aimed to describe the feasibility of home monitoring to assess blood pressure in primary care and compared differences between blood pressure values measured at home and in a clinical setting.

Methods

This cross-sectional study was carried out in 15 public basic health units (BHU) in the urban area of the city of Vitória da Conquista (BA), Brazil. This area is part of the HealthRise project that encompasses multidisciplinary actions at three levels of healthcare, focusing on screening and improving care in hypertension and diabetes[13].The inclusion criteria were all patients older than 18 years of age who were either:(1) awaiting diagnostic confirmation of hypertension with suspected WCH; (2) receiving antihypertensive treatment with difficult-to-control hypertension; or (3) were intolerant to ABPM.

Patients were excluded from the study if they: 1) performed less than 10 measurements; 2) had an arm circumference not supported by the HBPM device (less than 22 cm, or more than 32 cm); 3) suffered from atrial fibrillation or cardiac arrhythmia (identified by the first measurement performed in the office); 4) are pregnant women or had conditions that hampered the use of HBPM; for example, older adults with low levels of literacy who had no responsible person at home to assist with BP measurement.

Data were collected between August 2018 and February 2019. All patients who were eligible in that period and were invited to participate were included. It device used for performing HBPM was an automatic blood pressure monitor (MAM BP 3AC1-1 PC, Microlife), validated according to the British Hypertension Society (BHS) protocol[14]. The monitor performs three automatic measurements without removing or repositioningthe cuff and calculates the mean BP values. It also contains a memory that allows verification of the results by transferring the values to a database. To measure BP in health facilities an automatic device (Omron® HEM-7113) was employed. The measurements were carried out in a doctor's and/or nurse's office, or atout-of-office patient meetings promoted by the healthcare team.

Study participants were chosen during individual visits by doctors/nurses or out-of-office patient meetings. All BP measurements and clinical conducts were recorded in electronic medical

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records. Patients who met the inclusion criteria were invited to be subjected to HBPM.

All health professionals were trained for indications, instructions for operating the devices, guidelines for patients, completing the form, and using software for reading the BP values to minimize errors. This software allowed the transfer of data from the BP monitor including: BP measurements, the number of measurements performed, the times of each measurement, and of the calculated BP average.

A form with questions on identification data, age, use and description of medications used, BP measured at the time of BHU visit was administered to each eligible patient and previous diagnoses (e.g., diabetes or hypertension). Patients with diabetes were registered on the form as diabetic based on medical records, use of hypoglycemic agents, or self-reports. Hypertension patients were those previously diagnosed by the health unit's physician with two or more high BP values (SBP ≥ 140 mmHg and / or DBP ≥ 90 mmHg), on at least two occasions or HBPM abnormalities (≥ 135/85 mmHg). WCH were those with a diagnosis of hypertension, abnormal office measurement values(≥140 / 90 mmHg) and normal values by HBPM (≤135 / 85 mmHg). Only variables with less than 20% of values missing were included for analysis[15]. Other variables of interest were the number of BP measurements, mean systolic BP (SBP), and mean diastolic BP (DBP) values throughout the day (morning and evening).

The healthcare professionals completed this form and provided instructions on how to use and care for the device and maintain antihypertensive treatment. Patients took the HBPM device home and were instructed to perform three measurements in the morning and three measurements in the evening for seven days, totalling 42 readings and 14 BP means. All patients performed a test measurement upon receipt of the device to check for possible issues; this measurement was excluded at the time of issuing the results. As a strategy to prevent errors from occurring, verbal instructions were given during the allocation of the devices, along with written instructions and home visits on the days of use. Patients were instructed to perform HBPM in a quiet place, seated with their backs and arms supported and with at least five minutes of rest. After seven days of use the data were transferred and the report was issued by the software.

Any change in the mean BP would require the scheduling of a medical visit for a physical examination, diagnostic tests, and monitoring depending on the comorbidity presented. In addition, all patients with an HBPM mean ≥ 135x85mmHg were advised to make changes to their dietary habits, physical activity, or current therapy.

Data were analysed using SPSS Statistic 23 software. The Kolmogorov-Smirnov test was used to evaluate normality of the data. The paired T-Test was used to assess office BP measurements versus HBPM. Continuous variables with normal distribution were shown as means and standard deviations. The odds ratio was calculated to evaluate the variables associated with uncontrolled BP in the office and by HBPM. Values of $p<0.05$ were considered significant. Bland-Altman plots were generated by MedCalc (version 18.11.3) to visualize agreement between SBP/DBP in the office and HBPM.

This study was approved by the Research Ethics Committee of the Multidisciplinary Health Institute, Federal University of Bahia.

Results

A total of 142 patients evidenced HBPM indication criteria, of which eight were excluded because they did not provide a sufficient number of BP measurements by HBPM. The population evaluated consisted of 134 patients (Table 1).

The majority of participants were hypertensive, referred for antihypertensive therapy, and 73.8% of the requests for HBPM were intended for the monitoring of drug treatment.

The number of patients with elevated BP was higher than HBPM, as well as the mean values for SBP and DBP, as measured by health professionals. The mean SBP difference was 10.1 mmHg, and DBP was 4.3 mmHg ($p < 0.05$) (Table 2).

In the 134 patients, the prevalence of WCH was 19.4%. In patients with diabetes mellitus, this prevalence was 26.2%.

In all variables analysed, office BP was higher than the HBPM. Only ages ≤60 years showed a lower odds ratio (0.2) of high HBPM. The odds of obtaining an alternative HBPM result in patients with hypertension and diabetes was 2.7% (Table 3).

The Bland-Altman plots showed low agreement between measurements of office and HBPM (Figure 1). The mean differences drawn in the central lines were far from zero with values of 10 mmHg for SBP, and 4.4 mmHg for DBP, ($p< 0.01$).

Discussion

In this study we used HBPM to evaluate hypertension in primary care patients. Office BP was altered in 62.3% of the cases, while 48% of cases showed an alteration in home BP.

This difference may be related to factors such as environment, emotional state, and presence of observers during office BP measurements, and can be minimized when several measures of BP are performed by the patient at home[3,16,17]. Our study shows similar results to those of existing studies, in which HBPM provides more accurate values when compared to in-house assessment by health professionals[2,18,19].

The most common indication for using HBPM was to monitor drug therapy (73.8%). This is because it is possible to improve adherence to drug therapy, adjust dosage, and identify whether therapy is effective or causing adverse effects[4,20].

The HBPM device is easy to use, requires only a few minutes per day to perform measurements, records measurements automatically, does not cause discomfort, and is well accepted, including in older adults[11,21]. However, it is crucial that HBPM is prescribed with caution in patients with physical and cognitive restrictions[22], as improper handling of the device or inaccurate clamp placement may interfere with the quality of the measurement. In these cases, measurements performed by a trained family member is an effective alternative[22].

BP measured in the office was slightly higher, with mean differences of 10.1 mmHg and 4.3 mmHg for SBP and DBP, respectively; this corroborates the notion that SBP can vary up to 30mmHg when emotional factors are involved[23]. It is suggested that the office measurement tends to be high due toWCH. Furthermore, office BP measurement may be an unreliable technique for the diagnosis and monitoring of hypertension. This is because it is based only ona small number of measurements and can be influenced by environmental conditions[18]. Some studies have shown that the diagnosis of hypertension, based on only two measurements performed on separate occasions, may lead to an increase in false-positive results[24].

Due to the variability of BP, a concordance analysis was performed using the Bland-Altman plots, which best represent the difference between the two methods. Low agreement between HBPM and office BP was observed through the

Table 1. Characteristics of 134 participants, Home Blood Pressure Monitoring indications and results.

Features	N	%
Age (mean)	56.9	
Gender		
Female	93	69.4
Male	41	30.6
Hypertensive*		
Yes	100	76.9
No	18	13.8
Do not know	12	9.2
Diabetes*		
Yes	33	25.4
No	97	74.6
Use of medicines*		
Yes	114	87.7
No	16	12.3
HBPM indications		
Monitoring of antihypertensive therapy	96	73.8
White coat hypertension diagnosis	10	7.7
Hypertension diagnosis	24	18.5
Office and HBPM results		
Office Measurement ≥ 140x90 mmHg		
Yes	82	61.2
No	52	38.8
HBPM ≥ 135x85 mmHg		
Yes	65	48.5
No	69	51.5
White coat hypertension		
Yes	26	19.4
No	108	80.6

*Variables with missing values.

Source: Author´s elaboration.

Table 2. Office blood pressure versus Home Blood Pressure Monitoring measurements.

	BP office	HBPM	Mean difference	95% CI	p-value*
SBP	147 ± 21.3	136 ± 16.2	10.1±17	7.1-13.1	<0.05
DBP	87 ± 15.5	82 ± 10.6	4.3±12	2.2-6.4	<0.05

Source: Author´s elaboration.

Table 3. Patients variables associated with uncontrolled office blood pressure and by Home Blood Pressure Monitoring, Bahia Brazil 2018-2019.

	High BP office (%)	OR	p*	CI	Changed HBPM (%)	OR	p*	CI
N patients	82(63.3%)	-	-	-	65(48%)	-	-	-
Variable								
Age, ≤60 years	42 (51%)	0.4	0.01	0.1-0.8	26(40%)	0.2	0.01	0.1-0.4
Female, gender	54(65%)	0.5	0.20	0.2-1.3	47(72%)	1.3	0.40	0.6-2.7
Hypertension	67 (81%)	2.0	0.07	0.9-4.8	56(86%)	2.7	0.02	1.1-6.5
Diabetes	24(29%)	1.9	0.10	0.8-4.8	22(34%)	2.7	0.01	1.1-6.2
Use of medicines	76(92%)	3.5	0.01	1.1-10.4	59(93%)	3.2	0.04	0.98-10

*BP office: office blood pressure; HBPM: Home blood pressure monitoring.*chi-square test.*

Source: Author´s elaboration.

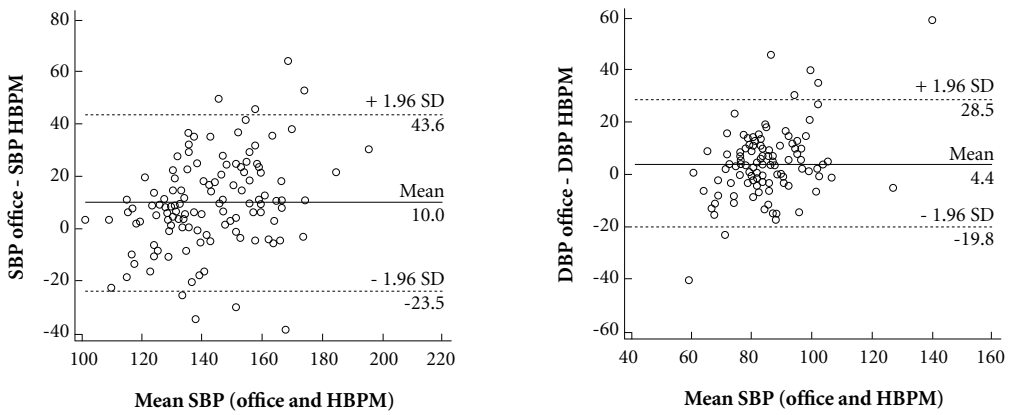

Figure 1. Analysis of bland-altman agreement between systolic and diastolic blood pressure (mmHg) values determined by home blood pressure monitoring and office blood pressure.

Source: Author's elaboration.

variations in mean BP between these two methods. This confirmed that the office measure overestimated BP values in these individuals.

In our patients, the rate of WCH was 19.4%, and although similar to other studies, this rate varies depending on the characteristics of the patients included[8]. A meta-analysis performed with a total of 14 studies showed that WCH is associated with an increased risk of cardiovascular disease and all-cause mortality in people who, initially, had not undergone antihypertensive treatment[25]. This is likely due to the linear association between BP levels and cardiovascular risk[26,27]. HBPM allows a precise diagnosis of WCH[11], reduces the number of visits to the doctor's office, prevents the inappropriate prescription of medication,and prevents effects associated with antihypertensive treatment, especially in older patients or those with multiple comorbidities[7].

Patients with diabetes mellitus accounted for 26.2% of those diagnosed with WCH which can be partially explained by arterial stiffness found in this patient cohort[2]. Indeed, HBPM has been studied in diabetic patients and it has been noted to be similar or superior to BP measured in clinical settings in predicting outcomes[2,4]. In addition, HBPM can be a strong independent predictor of impaired renal function in diabetics[2]. Therefore, the use of HBPM in diabetic patients is recommended as it is a tool capable of identifying variations in measurements, especially in lower blood pressure values.

A patient's non-compliance with home and follow-up measurements outlined in the mon-

itoring protocolmay influence the outcome of HBPM[16]. The number of days required to carry out the measurements remains controversial[28], and in our study, we preferredthe seven-dayperiod because it was a reliable approach.

HBPM is a new technology in Brazil, but it has been used for decades in developed countries[17]. Concerning feasibility, HBPM is not always available and rarely used in Brazil, as the training and qualifications required to perform this technique are not provided within the Brazilian health care system. Despite this, the HBPM was found to be a very effective strategy for WCH diagnosis, and analysis showed that HBPM requires less financial and practical investments when compared to ABPM[29]. An inter-domain evaluation of primary care providers has shown that the most critical barriers to conducting ABPM are related to costs, infrastructure, and inaccessibility of ABPM testing centres. Regarding HBPM, the primary concerns are related to patients' failure to comply with the test protocol, lack of skills, or insufficient knowledge for performing the measurements[18].

A study evaluating knowledge about ABPM and HBPM showed that only 60% of ABPM examinations are requested and that most physicians report having no technical knowledge for ABPM interpretation[12]. Another study with 756 physicians and 146 hypertensive patients revealed that 13% of professionals preferred BP self-monitoring compared to office measurement[9]. Unlike ABPM, HBPM is more widely accepted by patients, although it requires the patient to be committed incarrying out measurements, which can be a challenge for this monitoring strategy[28].

Our study has some limitations. Firstly, office BP measures were performed only on one occasionfor each patient, which may have overestimated the SBP and DBP values used as a reference for comparison with HBPM. Secondly, the number of measurements was not equitable in all healthcare professionals trained to perform HBPM. Thirdly, the turnover of professional staff within the service and the training needs of new staff may have influenced the population's access to HBPM. As we didn't follow the patients, we couldn't to understand change in prescribing or other behavior of clinicians in response to this data as part of the feasibility assessment.

Conclusion

The use of HBPM in the Brazilian healthcare system was a practicable strategy. It is superior to the office setting in confirming the diagnosis of WCH, as well as monitoring and diagnosing hypertension. This HBPM technology is more accessible than ABPM, better accepted by patients, and more reliable than office BP. Thus, strategies to implement HBPM for diagnosing and monitoring hypertension should be established in primary care.

Collaborations

We declare that all authors of this article participated directly in the planning, execution, reading and approval of this final version.

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