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Comparison and Correlation between Self-measured Blood Pressure, Casual Blood Pressure Measurement and Ambulatory Blood Pressure Monitoring

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Abstract

Background: Casual blood pressure (BP) measurement by healthcare professionals is subject to great variability and new methods are necessary to overcome this limitation.

Objective: To compare and assess the correlation between the BP levels obtained by self-measured BP (SMBP), casual BP measurement and ambulatory blood pressure monitoring (ABPM).

Methods: We assessed hypertensive individuals submitted to the three methods of BP measurement at an interval < 30 days; the BP means were used for comparison and correlation. The following devices were used: OMRON 705 CP (casual measurement), OMRON HEM 714 (SMBP) and SPACELABS 9002 (ABPM).

Results: A total of 32 patients were assessed, of which 50.09% were females, with a mean age of 59.7 (± 11.2), BMI mean of 26.04 (± 3.3) kg/m². Mean systolic (SBP) and diastolic blood pressure (DBP) for SMBP were 134 (± 15.71) mmHg and 79.32 (± 12.38) mmHg. The casual measurement means of SBP and DBP were, respectively, 140.84 (± 16.15) mmHg and 85 (± 9.68) mmHg. The mean values of ABPM during the wakefulness period were 130.47 (± 13.26) mmHg and 79.84 (± 9.82) mmHg for SBP and DBP, respectively. At the comparative analysis, the SMBP had similar results to those obtained at ABPM (p > 0.05) and different from the casual measurement (p < 0.05). At the analysis of correlation, SMBP values were higher than the casual measurements, considering ABPM as the reference standard in BP measurements.

Conclusion: SMBP showed a better correlation with ABPM than the casual measurement and was also better correlated with the latter, especially regarding the DBP and should be considered as a low-cost alternative for the follow-up of the hypertensive patient. (Arq Bras Cardiol 2011; 97(2) : 148-155)

Keywords: Hypertension; blood pressure; blood pressure monitoring, ambulatory, self-care.

Introduction

Arterial hypertension is an important risk factor for cardiovascular diseases and directly and indirectly contributes to the high morbimortality in both developed and developing countries[1,2]. In this context, the accurate measurement of blood pressure (BP) levels is of utmost importance for risk stratification and to define the adequate therapeutic strategy, being important to seek alternatives for the great variability of BP in the presence of stress factors , such as for instance, during a consultation with the healthcare professional[3,4].

The indirect measurement of BP at the medical office (casual measurement) is considered the standard procedure for the diagnosis and follow-up of hypertensive patients with predictive value for cardiovascular morbidity and mortality.

However, when compared with the BP monitoring methods, it is considered inferior. That fact can be explained by the limitations of the casual measurement, which include from the examiner's influence (measurement bias, white-coat effect) to the environment where the measurement is carried out and the reduced number of readings with low reproducibility in the long term[5-8].

Among the monitoring methods, the ambulatory blood pressure monitoring (ABPM) is considered the reference standard, allowing the assessment of BP during daily routine activities in the wakefulness period and during sleep, therefore allowing a larger number of readings to be obtained, as well as the knowledge of the BP variability and nocturnal dipping during sleep. The home blood pressure monitoring (HBPM) is another acknowledged method, characterized by having well-established protocols (certain number of BP readings in the morning and at night), having the advantage of yielding a higher number of readings outside the medical office environment and good patient adherence[9]. Studies indicate that BP means obtained by ABPM and HBPM are lower than those obtained at casual measurements, are more accurate in

the diagnosis and better predict cardiovascular risk; however, these are expensive and little accessible methods for our hypertensive patients[10-12].

A third method of BP monitoring, the self-measured blood pressure (SMBP), is the objective of the present study. There have been few publications on this method to date. Its characteristic is the absence of pre-established protocols - the patient him- or herself performs random measurements at home, in validated automatic or semiautomatic digital blood pressure devices for home use. This is a low-cost, easy-to-use method and there is the possibility of preventing reading error[13,14], thus justifying carrying out this study to assess BP measurements obtained at SMBP and compare them with casual measurements and ABPM, considering that this method might constitute in a near future, a low-cost and feasible method to monitor hypertensive patients.

Objectives

To compare e correlate BP levels obtained by SMBP with casual measurements and ABPM.

Methods

Research project #144/07 was evaluated and approved by the Ethics Committee in Human and Animal Medical Research of *Hospital das Clínicas da Faculdade de Medicina da Universidade Federal de Goiás* (UFG). The participants were informed on the study procedures and signed the Free and Informed Consent Form.

The present is the prospective study of a sample consisting of patients being followed at the Arterial Hypertension League, who were invited to undergo casual BP measurements, ABPM and SMBP, with an interval < 30 days between the methods (n = 32).

Inclusion criteria involved adult patients of both sexes (aged 18 to 70 years) with arterial hypertension, undergoing drug treatment and regular follow-up during scheduled visits (the enrollment criterion was attending all consultations during the previous year). The exclusion criteria included impossibility or refusal to sign the informed consent form, participation in other research protocols, patients with end-stage chronic diseases, those with stage III hypertension[8] or refractory hypertension, obesity (BMI > 30 kg/m²), heart arrhythmia, history of cardiocirculatory events in the last six months (acute myocardial infarction, cerebrovascular accident, transient ischemic accident), chronic kidney failure, decompensated heart failure, decompensated diabetes, other diseases that were considered by the investigator as possible compromising factors for the study, secondary hypertension and hormonal replacement therapy that had not been at a stable dose for at least six months.

The anthropometric parameters were assessed as follows:

Body mass - Subjects wore light clothes and no shoes; a Toledo electronic scale with 100-g precision was used.

Height - Subjects were barefoot; a Filizola stadiometer with a 1-mm precision was used.

Body mass index (BMI) - Calculated using the formula established by QUETELET (BMI - weight in kg/height² in meters).

The methods employed to measure BP were as follows:

- *Casual BP measurement in the medical office* - Carried out according to the techniques recommended by VI DBHA, 2010[8]. BP was measured with an automatic digital sphygmomanometer (OMRON 705 CP), with the patient in the sitting position, after a 10-minute rest, with the arm supported and at the level of the precordium. Two measurements were carried out in the morning, always by the same examiner, with a 2-minute interval between them; the mean value was considered for the analysis.

- *Self-measured BP* - At the start of the study, the patients received a semi-automatic OMROM HEM 714 device for systematic BP measurement. It was established that the measurement should be carried out in the morning, between 8 AM and 10 AM, or in the evening, between 6 PM and 8 PM, in at least two days a week. Additional measurements could be taken at patients' discretion, but they were not used for the calculation of means. Patients were trained prior to the use of the device according to the recommendations by the VI DBHA and it was carried out by the authors of this protocol. Eight consecutive measurements (one month's worth) taken after the medical consultation were used to calculate the mean BP values.

- *ABPM* - Carried out with the Spacelabs 9002 Monitor, with measurements being standardized every 15 minutes during the wakefulness period and every 20 minutes during sleep. The data were considered valid when the monitoring was carried out for a minimum period of 21 hours, with a minimum number of sixteen measurements during wakefulness and eight during sleep. Patients were advised to make a journal and note down all activities carried out during the period and time of drug administration[9]. When the ABPM was removed, the report was printed and a medical report was made. The latter was filed together with the printed report in the patient's file. All measurements obtained were considered for the calculation of 24-hour means; to calculate the means during wakefulness, measurements obtained between 7 AM and 11 PM were considered; to calculate the means during the sleep period, measurements obtained between 11 PM and 7 AM were considered.

The data were stored and structured using the MS Excel program. The statistical analysis was carried out using the SPSS (*Statistical Package of Social Science*) software for Windows release 15.0. Kolmogorov-Smirnov test was used to analyze whether the numerical variables had a normal distribution. The t test for paired samples was used to compare means, numerical variables and Pearson's correlation was used to assess the correlation between self-measured BP and ABPM and the casual BP measurement in the office.

Results

A total of 32 patients were assessed, of which 50.09% were females and the mean age was 59.7 (± 11.2) years. BMI mean 26.04 (± 3.3) kg/m².

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The mean values of systolic (SBP) and diastolic blood pressure (DBP) found by self-measured BP were 134.00 (± 15.71) mmHg and 79.32 (± 12.38) mmHg, respectively. As for the casual measurement, mean SBP was 140.84 (± 16.15) mmHg, and mean DBP was 85.00 (± 9.68) mmHg. Mean BP values at ABPM during wakefulness were 130.47(± 13.26) mmHg and 79.84 (± 9.82) mmHg for SBP and DBP, respectively (Tables 1 and 2).

When comparing BP means, significant differences were observed between ABPM and casual measurements, for both SBP (p = 0.031) and DBP (p = 0.003) (Table 1).

When comparing SMBP with ABPM during wakefulness, no differences were observed between SBP and DBP means (p = 0.064 and p = 0.719) (Table 2).

There was a significant correlation between SMBP and casual measurements for both SBP and DBP (p < 0.017 and p < 0.000, respectively), as well as between SMBP and ABPM during wakefulness (p < 0.000 for SBP and DBP). However, the best correlation was found between values obtained by SMBP and ABPM during wakefulness, for both SBP and DBP (r = 0.755 and 0.753) in comparison to those obtained by SMBP and casual measurements for SBP and DBP, respectively (r = 0.419 e r = 0.609). No correlation was observed between SBP values obtained in the casual measurement and those obtained by ABPM during wakefulness (p = 0.227); there was a significant correlation only with the DBP in this case (p < 0.000) (Figures 1, 2 and 3).

Discussion

Casual blood pressure measurement by healthcare professionals has been the mainstay of the diagnosis and follow-up of the hypertensive patient for more than one hundred years. However, it is necessary to face the limitations and weaknesses of this method, considering the large BP variability that occurs throughout the day, the effect of several interferences on BP values caused by diverse situations and the correlation of these facts to the small number of measurements that are performed when using this method[15,16].

Table 1 - Comparison between self-measured and casual BP measurement (n = 32)

	Self-measured	Office	p
SBP (mmHg)	134 ± 15.71	140.84 ± 16.15	0.031
DBP (mmHg)	79.32 ± 12.38	85 ± 9.68	0.003

Student's t Test. Values expressed as mean ± standard deviation. SBP - systolic blood pressure; DBP - diastolic blood pressure; mmHg - millimeters of mercury.

Table 2 - Comparison between self-measured BP and ABPM (during wakefulness)

	Self-measured BP	ABPM (wakefulness)	p
SBP (mmHg)	134 ± 15.71	130.47 ± 13.26	0.064
DBP (mmHg)	79.32 ± 12.38	79.84 ± 9.82	0.719

Student's t Test. Values expressed as mean ± standard deviation. SBP - systolic blood pressure; DBP - diastolic blood pressure; mmHg - millimeters of mercury.

A series of other factors can also interfere with isolated measurements obtained by healthcare professionals in the medical office and these can depend on the examiner, the patient or the device, resulting in situations that often do not represent the individual's actual BP levels[17,18]. In this context, the masked hypertension will not be diagnosed if methods that allow BP measurement outside the office environment are not used, and, consequently, these patients with increased cardiovascular risk will not be adequately treated[19,20]. On the other hand, and due to the same method limitation, patients with white-coat hypertension will receive unnecessary treatment[21].

Ambulatory blood pressure monitoring (ABPM) is a method that allows a higher degree of precision in patient diagnosis and follow-up[4,14,15,17]. However, the use of this methodology in all hypertensive patients would be too costly and unfeasible from the point of view of the public health system. The limitations described herein indicate the need for other methodologies that allow BP measurement outside the hospital or ambulatory environment that are low-cost and reliable and can supply BP values without the influence of the healthcare professional as observer. These are the characteristics of self-measured blood pressure (SMBP).

The self-measured BP represented by the model adopted in the present study has yielded few publications in national and international journals. What is frequently found in the literature is a reference to the term SMBP (self-measured blood pressure or home-measured blood pressure) as the equivalent to home blood pressure monitoring, which includes advice on how to use the devices according to pre-established protocols . In this sample, the patients were advised to perform a minimum of two weekly BP measurements, but they were free to perform additional ones. Corroborating the methodology used in the present study, the guidelines of the European Society of Hypertension recently recommended that two weekly BP measurements with validated devices could be used for the long-term follow-up of hypertensive patients[22].

Our objective was not to analyze cardiovascular outcomes; we tested the hypothesis that the BP measurement carried out by the patient in the home environment, using validated devices with no pre-established protocols would have a better correlation and comparison with ABPM than the casual BP measurement, which was confirmed.

The question regarding the reliability and reproducibility of SMBP has been previously tested, but with pre-established measurement protocols and satisfactory results for this type of analysis, even concerning the prediction of cardiovascular outcomes[22-24].

Our results show that BP values in SMBP are lower than those obtained by the casual measurement and closer to those obtained by ABPM during wakefulness. Moreover, SMBP has good correlation with both methodologies. These findings indicate good perspectives for this method in the follow-up of hypertensive patients, being capable of attenuating several measurement biases that occur when only the casual measurement is used and allowing a higher number of individuals to have access to BP monitoring[25].
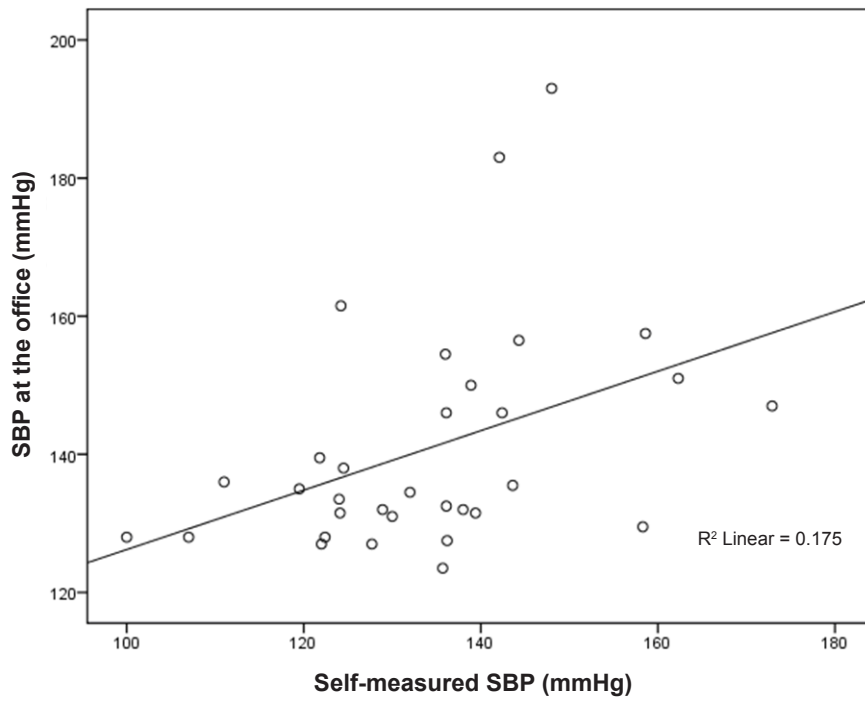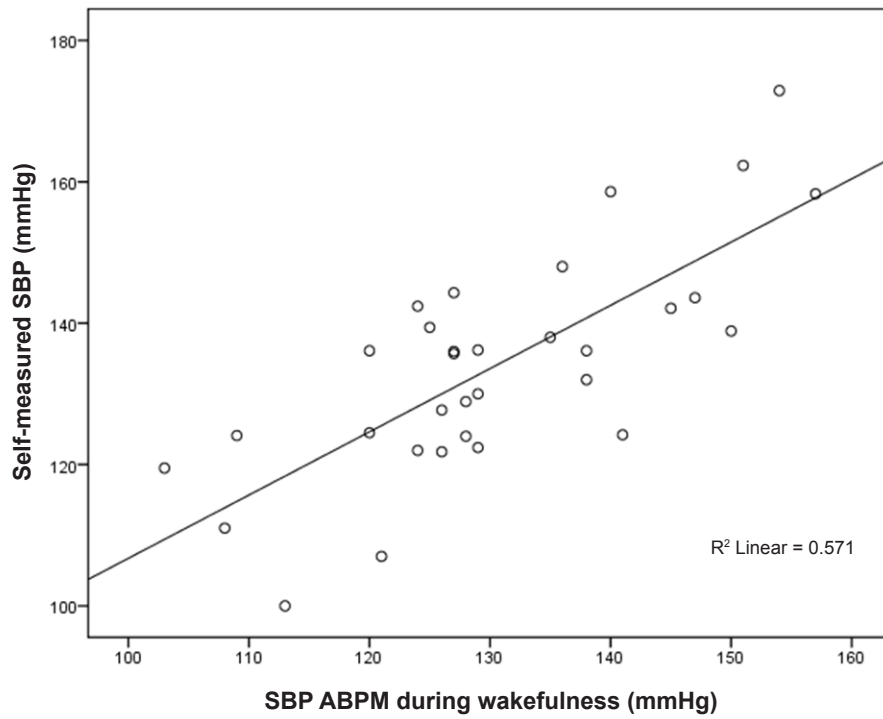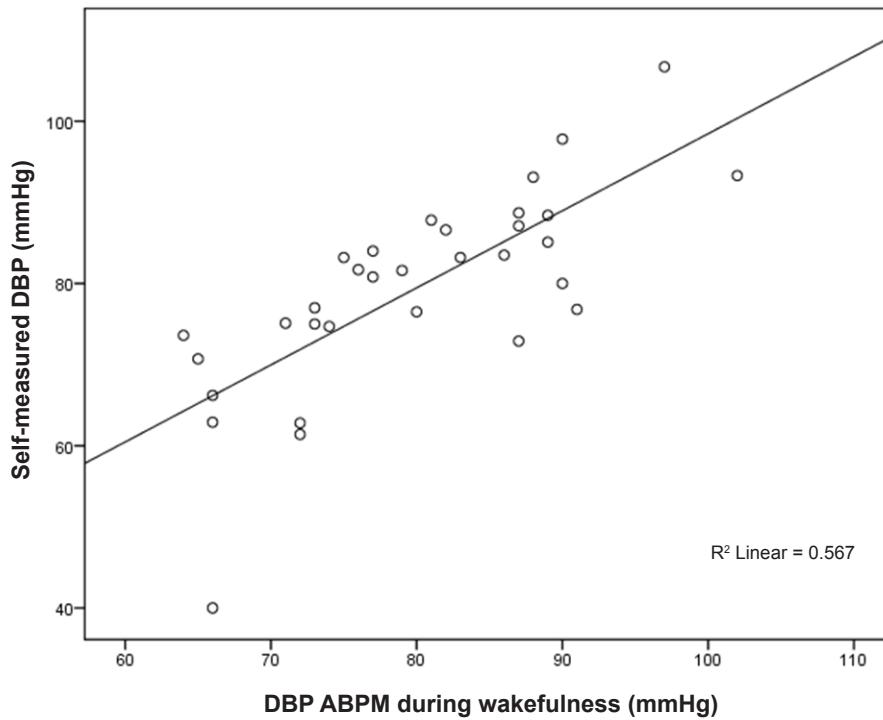
Pearson's correlation; r = 0.419 and p < 0.017.
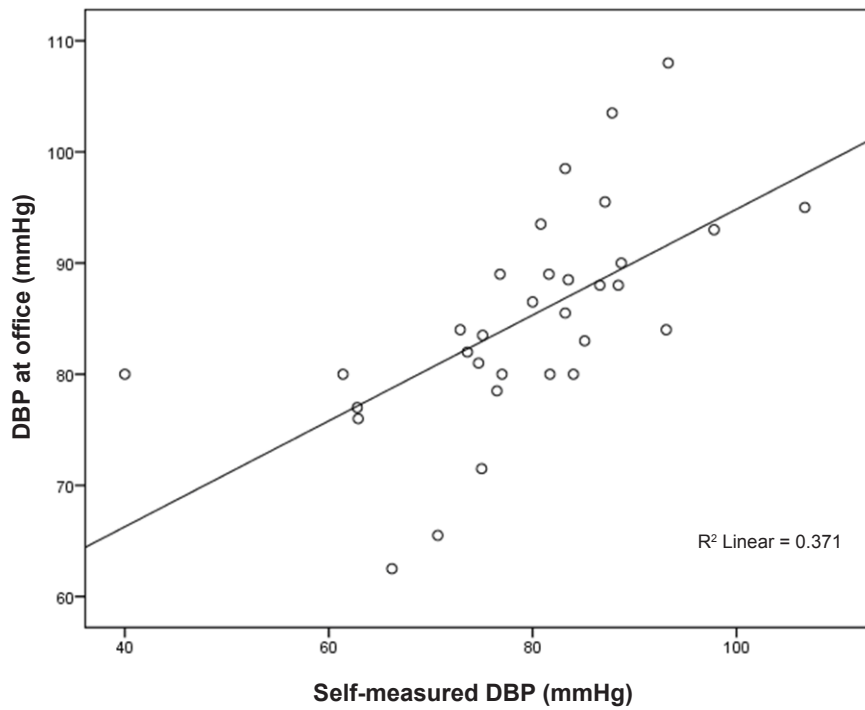
Pearson's correlation; r = 0.609 and p < 0.000.

Figure 1 - *Correlation between casual BP measurement and AMBP.*
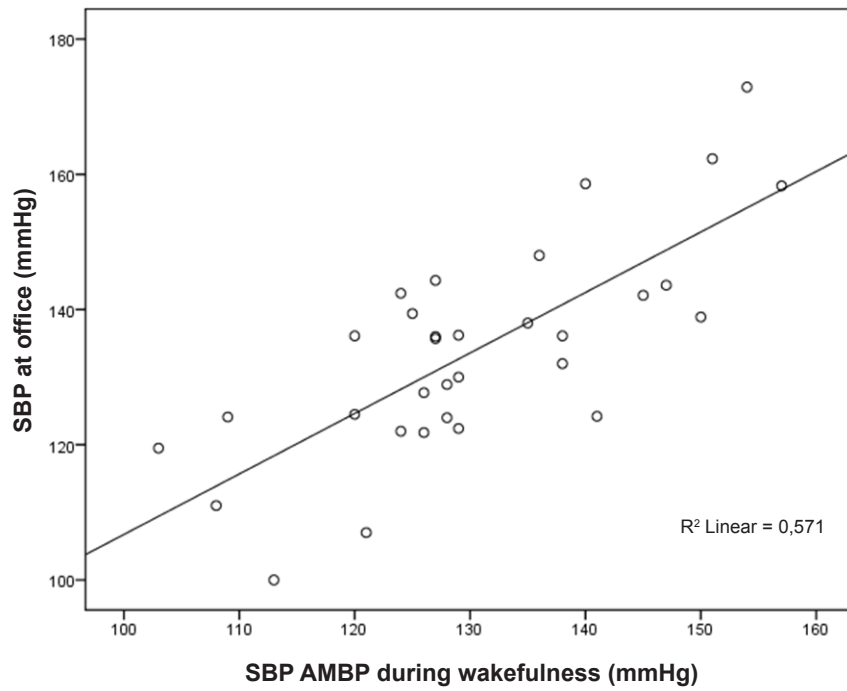
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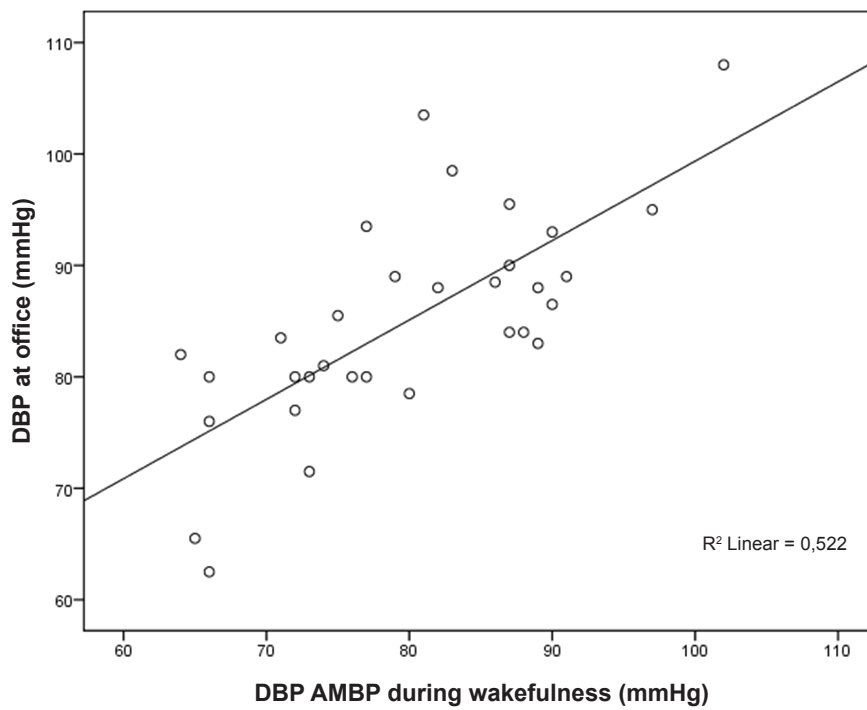

Pearson's correlation; r = 0.755 and p < 0.000.

Pearson's correlation; r = 0.753 and p < 0.000.

Figure 2 - Correlation between SMBP and AMBP (wakefulness).

Pearson's correlation; r = 0.220 and p = 0.227.

Pearson's correlation; r = 0.723 and p < 0.000.

Figure 3 - *Correlation between casual pressure and ABPM (wakefulness).*

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Another publication demonstrated that SMBP, in addition to having a better correlation and comparison with ABPM than the casual measurement, is also a better predictor of left ventricular hypertrophy risk in hypertensive patients[22], which supports its usefulness in the routine follow-up of these patients. Therefore, the perspective of using this method seems quite attractive and deserves to be further studied, with a great probability of having it incorporated as an alternative for the follow-up of the hypertensive patient.

The superiority of ABPM and HBPM in comparison to casual BP measurement has been demonstrated[15,25] and guidelines have even recommended a more frequent use of these methods[26]. Recently, some studies recommended that BP measurements outside the ambulatory environment, carried out by the patients with validated devices should be increasingly more used, taking into account that this methodology shows advantages in the follow-up and treatment of arterial hypertension[9,17,22,27-29].

This recommendation can represent, in a near future, a change in the paradigm of blood pressure measurement and control, as patients would have active and more important roles regarding the awareness and follow-up of their BP levels, perhaps with a positive impact on adherence and BP control rates.

Conclusion

These findings indicate the possibility of using SMBP as an alternative method to monitor BP in the hypertensive population, with better comparison and correlation with ABPM than the casual BP measurement.

Study limitations

The number of patients assessed in this study is small and other analyses with larger sample sizes are necessary. In spite of that fact, the statistical significance in both the comparison and correlation analyses leads us to believe that the conclusions of the present study are pointing toward the correct direction.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

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Study Association

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References

1. Stokes J, Kannel WB, Wolf PA, D'Agostino RB, Cupples LA. Blood pressure as a major risk factor for cardiovascular disease: the Framinghamn study. 30 years of follow-up. Hypertension. 1989;13(5 Suppl): I13-8.

2. Mathers CD, Bernard C, Iburg KM, Innoue M, Fat DM, Shibuya K, et al. Global burden of disease in 2002: data sources, methods and results. Geneva: World Health Organization; 2003. (Global Programme on Evidence for Health Policy Discussion Paper n. 54).

3. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. The JNC 7 Report. JAMA. 2003;289(19):2560-72.

4. O`Brien E, Asmar R, Beilin L, Imai Y, Mancia G, Mengden T, et al. Practice guidelines of the European Society of Hypertension for clinic, ambulatory and self blood pressure measurements. J Hypertens. 2005;23(4):697-701.

5. Wolf-Maier K, Cooper RS, Kramer H, Banegas JR, Giampaoli S, Joffres MR, et al. Hypertension treatment and control in five European countries, Canada, and the United States. Hypertension. 2004;43(1):10-7.

6. Jardim PCBV, Monego ET, Reis MA, Souza ALL. Aspectos históricos e tendências atuais na medida da pressão arterial. Rev Bras Hipertens. 2000;7(1):25-30.

7. Souza ALL, Monego ET. Manual de técnicas: medidas da pressão arterial e avaliação nutricional. Goiânia: CEGRAF; 1996.

8. VI Diretrizes brasileiras de hipertensao arterial. Rev Bras Hipertens. 2010;17(1):1-64.

9. Alessi A, Brandão AA, Pierin A, Feitosa AM, Machado CA, de Moraes Forjaz CL, et al. IV Diretriz para uso da monitorização ambulatorial da pressão arterial. II Diretriz para uso da monitorização residencial da pressão arterial IV MAPA/II MRPA. Arq Bras Cardiol. 2005;85(supl 2):1-18.

10. Pickering TG, James GD. Ambulatory blood pressure and prognosis. J Hypertens Suppl. 1994;12(8):S29-33.

11. Verdecchia P, Porcellati C, Schillaci G, Borgioni C, Ciucci A, Battistelli M, et al. Ambulatory blood pressure: an independent predictor of prognosis in essential hypertension. Hypertension. 1994;24(6):793-801.

12. Clement DL, De Buyzere ML, De Bacquer DA, Duprez DA, Fagard RH, Missault LH, et al. Prognostic value of ambulatory blood-pressure recordings in patients with treated hypertension. N Engl J Med. 2003;348(24):2407-15.

13. Martin GM, Parati G. Self measure blood pressure in the office and at home. J Hypertens. 2003;21(12):2223-5.

14. Verberk WJ, Kroon AA, Jongen-Bancraybex HA, De Leeuw PW. The applicability of home blood pressure measurement in clinical practice: a review of literature. Vasc Health Risk Manag. 2007;3(6):959-66.

15. Parati G, Stergiou GS, Asmar R, Belo G, de Leew P, Imui Y, et al. European Society of Hypertension guidelines for blood pressure monitoring at home: a summary report of the Second International Consensus Conference on Home Blood Pressure Monitoring. J Hypertens. 2008;26(8):1505-26.

16. O`Brien E. Ambulatory blood pressure measurement: the case for implementation in primary care. Hypertension. 2008;51(6):1435-41.

17. O´Brien E, Asmar R, Beilin L, Imai Y, Mancia G, Mengden T, et al. Practice guidelines of the European Society of Hypertension for clinic, ambulatory and self blood pressure measurement. J Hypertens. 2005;23(4):697-701.

18. Stergiou G, Mengden T, Padfield PL, Parati G, O'Brien E. Self monitoring of blood pressure at home. BMJ. 2004;329(7471):870-1.

19. Fagard RH, Celis H. Prognostic significance of various characteristics of out-of-the-office blood pressure. J Hypertens. 2004;22(9):1663-6.

20. Bobrie G, Clerson P, Menard J, Vinay NP, Chatellier G, Plouin PF. Masked hypertension: a systematic review. J Hypertens. 2008;26(9):1715-25.

21. Banegas JR, Segura J, Sobrino J, Rodrigues-Artalejo F, De La Sierra A, De La Cruz JJ, et al. Effectiveness of blood pressure control outside the medical setting. Hypertension. 2007;49(1):62-8.

22. Parati G, Stergiou GS, Asmar R, Bilo G, de Leeuw P, Imai Y, et al. European Society of Hypertension practice guidelines for home blood pressure monitoring. J Hum Hypertens. 2010;24(12):779-85.

23. Myers MG, Parati G. Self-measurement of blood pressure in the office and at home. J Hypertens. 2003;21(12):2223-5.

24. Oikawa T, Obara T, Okhubo T, Kikuya M, Asayama K, Metoki H, et al. Characteristics of resistant hypertension determined by self-measured blood pressure at home and office blood pressure measurements: The J-HOME study. J Hypertens. 2006;24(9):1737-43.

25. Asayama K, Ohkubo T, Kikuya M, Metoki H, Obara T, Hoshi H, et al. Use of 2003 European Society of Hypertension – European Society of Cardiology Guidelines for predicting stroke using self-measured blood pressure at home: the Ohasama Study. Eur Heart J. 2005;26(19): 2026-31.

26. Staessen JA, Thijs L, Ohkubo T, Kikuya M, Richart T, Boggia J, et al. Thirty years of research on diagnostic and therapeutic thresholds for the self-measured blood pressure at home. Blood Press Monit. 2008;13(6):352-65.

27. Asmar R, Zanchetti A. Guidelines for the use of self-blood pressure monitoring: a summary report of the First International Consensus Conference Groupe Evaluation and Measurement of the French Society of Hypertension. J Hypertens. 2000;18(5):493-508.

28. Coca A, Bertomeu V, Dalfó A, Esmatjes E, Guillen F, Guerrero L, et al. [Blood pressure self measurement: Spanish consensus document]. Nefrologia. 2007;27(2):139-53.

29. Maldonado J, Pereira T, Estudo AMPA. Auto-medição da pressão arterial – análise preliminar do Estudo AMPA. Rev Port Cardiol. 2009;28(1):7-21.