Definition of Hypertension: The Impact of Number of Visits for Blood Pressure Measurement [61]

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ABSTRACT

Introduction: A diagnosis of hypertension should be based on multiple blood pressure (BP) measurements, taken on at least two separate occasions. We aimed to assess the impact of considering different criteria for a definition of hypertension, based on number of visits for blood pressure measurement, on estimates of hypertension prevalence, awareness, treatment and control, and on its association with two variables definitely related to hypertension: body mass index and left ventricular hypertrophy.
Methods: We used data from a cross-sectional study of 739 participants, aged ≥45 years, randomly selected from a non-institutionalized Portuguese population, from January 2001 to December 2003. Main outcome measures were prevalence of hypertension (systolic BP ≥140 mmHg and/or diastolic BP ≥90 mmHg or current antihypertensive drug therapy) based on BP measurements on one visit, on BP measurements on a second visit or on fulfilling the same criteria on the two different visits.
Results: Estimated hypertension prevalence was 63.4% (95% CI:59.8-66.9) using BP measurements from the first visit (HTN_1) and 60.2% (95% CI: 56.6-63.8) using BP measurements from the second visit (HTN_2). If both visits are used as criteria the estimated hypertension prevalence (HTN_{Final}) was 56.3% (95% CI: 52.7-60.0), p (McNemar test) <0.001, between HTN_1 and HTN_{Final} and between HTN_2 and HTN_{Final}. Awareness,

RESUMO

Definição de hipertensão: o impacto do número de visitas por medição de pressão arterial.

Introdução: O diagnóstico de hipertensão deve basear-se em múltiplas medições de pressão arterial (PA), obtidas em, pelo menos, duas visitas diferentes. Pretendemos avaliar e quantificar o impacto causado pela utilização de diferentes critérios para a definição de hipertensão, baseado no número de visitas para medição da PA, na estimativa de prevalência de hipertensão, no conhecimento, tratamento e controlo e na associação da hipertensão com duas variáveis com que está comprovadamente associada: o índice de massa corporal e a hipertrofia ventricular esquerda.
Material e Métodos: Os dados da amostra foram recolhidos num estudo transversal com 739 participantes, com idade ≥ 45 anos, seleccionados de forma aleatória de uma população Portuguesa, não institucionalizada, de Janeiro de 2001 a Dezembro de 2003. As principais medidas a estudar eram a prevalência de hipertensão (PA sistólica ≥140 mmHg e/ou PA diastólica ≥90 mmHg ou medicação com fármacos antihipertensores) baseada nas medições de PA numa primeira visita, numa segunda visita e cumprindo os mesmos critérios nas duas visitas.
Resultados: A estimativa de prevalência de hipertensão era 63.4% (95%CI:59.8-66.9)

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treatment and control changed from 60.2% to 64.4%, 53.1% to 59.8% and 24.9% to 22.0%, respectively, when using information from the first or both visits. All three different estimates of hypertension prevalence have a similar strong and independent association with body mass index (OR=2.71 for body mass index ≥30 with HTN_{Final}) and with left ventricular hypertrophy (OR=3.21 for HTN_{Final} with left ventricular hypertrophy).

Discussion and Conclusions: In many individuals labeled as hypertensive on a single evaluation, hypertension was not confirmed on reassessment, leading to a significant overestimation of 12.6% of the true prevalence. For this reason BP should be measured on at least two office visits both for clinical purposes and in epidemiological studies. On the other hand, this did not reflect on the association between hypertension and body mass index or left ventricular hypertrophy, suggesting that unconfirmed cases do not necessarily imply misclassification.

Key words

Hypertension; Blood pressure; Prevalence; Awareness; Treatment; Control; Measurement; Estimation; Body mass index; Left ventricular hypertrophy.

usando as medições de PA da primeira visita (HTA_1) e era 60.2% (95%CI:56.6-63.8) usando as medições de PA da segunda visita (HTA_2). Usando critério das duas visitas a estimativa de prevalência de hipertensão (HTA_{Final}) era 56.3% (95%CI: 52.7-60.0), p (McNemar) <0.001, entre HTA_1 e HTA_{Final} e entre HTA_2 e HTA_{Final}. O conhecimento, tratamento e controlo da hipertensão variou de 60.2% para 64.4%, 53.1% para 59.8% e 24.9% para 22.0%, usando a informação de uma visita ou das duas visitas, respectivamente. Ambas as estimativas tinham uma associação forte e independente com o índice de massa corporal (OR=2,71 para o índice de massa corporal ≥ 30 kg/m^2 com HTA_{Final}) e com a hipertrofia ventricular esquerda (OR=3,21 para a HTA_{Final} com a hipertrofia ventricular esquerda).

Discussão e Conclusão: Em muitos indivíduos considerados hipertensos numa avaliação única, a hipertensão não se confirmou na segunda avaliação, sobrestimando a sua prevalência, significativamente, em 12,6%. Por este motivo a medição de PA deve ser feita sempre em pelo menos duas visitas diferentes, quer com objectivos clínicos, quer em estudos epidemiológicos. No entanto, este facto não se reflectiu na associação entre hipertensão e o índice de massa corporal ou a hipertrofia ventricular esquerda, sugerindo que a não confirmação da hipertensão numa segunda avaliação pode não implicar necessariamente uma classificação errada.

Palavras-Chave

Hipertensão; Pressão arterial; Prevalência; Conhecimento; Tratamento; Controlo; Medição; Estimativa; Índice massa corporal; Hipertrofia ventricular esquerda.

INTRODUCTION

Blood pressure (BP) is characterized by considerable variation within and between days[1-3]. Both the JNC 7 recommendations[4] and ESH/ESC guidelines[1] recommend that the diagnosis of hypertension (HTN) should be based on the mean of two or more properly measured BP readings on each of two or more visits. However, implementation of this recommendation is very difficult in large epidemiological studies, and the definition of hypertension relies on only one or two readings at a single visit in most population surveys[5]. This can lead to an overestimation of the prevalence of hypertension and consequently underestimation of awareness and treatment[3,6-8]. Many factors can influence this overestimation, of which the major ones are within-person

variability[2,9], regression to the mean[8] and the "white-coat" effect[9,10].

In Portugal, the prevalence of hypertension[11] and incidence of stroke are high compared with other western European countries[12]. The incidence of transient ischemic attacks in Northern Portugal ranks among the highest reported in community-based studies[12]. The accuracy of hypertension prevalence estimates is essential for decisions on intervention policy and to evaluate the success of community control of hypertension.

Prospective cohort studies as well as national surveys have shown that overweight/obese individuals have an increased risk of hypertension[13] and that hypertension is a major risk factor for both left ventricular hypertrophy (LVH)[14] and cardiovascular disease[15]. As the association between overweight/obesity and hypertension and hypertension and LVH is consistently established, we can use this premise to evaluate different criteria for a definition of hypertension. The best hypertension definition should maximize the association with these variables.

We aimed to assess the impact of considering two criteria for a hypertension definition, based on BP measurements on one or two separate occasions, in an office environment, on the estimate of hypertension prevalence and on levels of awareness, treatment and control. Secondarily, we aimed to assess the influence of the definition of hypertension on its association with body mass index (BMI) and LVH, two variables definitely related to hypertension.

METHODS

Study Sample

As part of a cross-sectional health survey, a representative sample of the non-institutionalized adult population of Porto, Portugal, was selected by random digit dialing. A detailed description of the study has been published[16]. Within this sample, 739 consecutive participants aged ≥45 years, recruited from January 2001 to December 2003, were included in a specific research project, aiming to measure the prevalence of heart failure in this population[17].

The investigation conforms to the principles in the Declaration of Helsinki. The local ethics committee approved the study and participants provided written informed consent.

Data collection

The participants were evaluated twice, first with a general interview and then in a specific medical examination, with a median (interquartile range) interval between the two evaluations of 14 (6-35) days. Blood pressure was measured on both occasions.

Trained interviewers (technicians) collected data using a structured questionnaire and measured BP on the first visit in the morning, after the early-morning period and 12-hour overnight fast. The interviewers participated in repeated special training and retraining sessions on the use of a standardized BP measurement protocol using a mercury sphygmomanometer. Participants were instructed to take their medication and not to take alcohol, tea or coffee or to smoke or exercise within the 30 minutes preceding the measurement. Two BP measurements, separated by at least 5 minutes, were taken in an office, with a mercury sphygmomanometer, after a 10-minute rest in a quiet room, with no tight clothing, on the right upper arm, in a sitting position with the cuff at heart level. A standard bladder (12-13 cm long and 35 wide) was used but a larger and a smaller bladder were available for fat and thin arms respectively. The mean was considered and when the difference was larger than 5 mmHg for systolic or diastolic BP a third measurement was taken and the mean of the two closest values was registered. Korotkoff sounds were used to identify systolic BP, the point at which the first of two or more sounds is heard (phase 1) and diastolic BP, the point before the disappearance of sounds (phase 5). All participants had an anthropometric evaluation.

A few days after the first interview a second assessment by a physician took place in the afternoon (second visit). It consisted of a structured clinical interview, a cardiovascular physical examination and a transthoracic echocardiogram. Blood pressure was measured according to the same protocol and physicians attended the same training sessions on the use of a standardized BP measurement protocol using a mercury sphygmomanometer. The devices were the same on both occasions and were periodically checked for technical problems.

Echocardiograms were performed by four cardiologists using the same equipment (HP Sonos 5500). Measurements of wall thickness and chamber dimension were obtained according to the Penn convention[18].

Definitions

Hypertension was defined as systolic BP ≥140 mmHg and/or diastolic BP ≥90 mmHg and/or current antihypertensive drug therapy.

We used different criteria to estimate the prevalence of hypertension: one was based on the mean of BP measurements on the first visit (HTN_1), another was based on the mean of BP measurements on the second visit (HTN_2), and a third estimate was based on fulfilling the same criteria of hypertension on both visits (HTN_{Final}). Treatment of hypertension, defined as current use of antihypertensive drug therapy, was determined by review of all medication taken. Awareness of hypertension was defined as answering "yes" to the question: "Have you ever been told by a doctor that you have high BP?". Control was defined as the proportion of subjects under antihypertensive drug therapy with systolic BP <140 mmHg and diastolic BP <90 mmHg. When hypertension was defined using the criteria based on two evaluations, control was defined as systolic BP <140 mmHg and diastolic BP < 90 mmHg in both evaluations.

BMI was calculated as weight (kilograms) divided by the square of height (meters) and categorized according to the World Health Organization criteria[21]: underweight: <18.5 kg/m^2; normal weight: 18.5-24.9 kg/m^2; overweight; 25.0-29.9 kg/m^2; obese: ≥30 kg/m^2.

Left ventricular mass (LVM) was calculated by the equation 1.04 [(interventricular septum wall thickness + end-diastolic left ventricular internal diameter + posterior wall thickness)^3 - (end-diastolic left ventricular internal diameter)^3] - 13.6[18] using wall thickness and chamber dimensions measured by echocardiography, and normalized to body surface area. LVH was considered to exist when the LVM index was equal to or exceeded 125 g/m^2 in men and 110 g/m^2 in women[1].

Statistical analysis

Data are expressed as means (standard deviation) for normally distributed quantitative variables, medians (interquartile range) for non-normally distributed quantitative variables and proportions for categorical variables. Proportions in independent samples were compared using the chi-square test. Paired proportions were compared using the McNemar test.

Multivariate logistic regression was used to assess the association between BMI and HTN (HTN_1, HTN_2 and HTN_{Final}) and between HTN (HTN_1, HTN_2 and HTN_{Final}) and LVH, with HTN and LVH as dependent variables, respectively. Results are presented as odds ratios (OR) and 95% confidence intervals (95% CI). BMI was modeled as a categorical variable, using normal weight (18.5-24.9 kg/m^2) as reference, adjusted for gender and education. LVH was modeled as a dichotomous variable adjusted for age and BMI.

We also compared the age- and gender-adjusted prevalence of LVH, stratified by BMI class, in three groups: without hypertension on either visit (no HTN), with hypertension only on the first visit (unconfirmed HTN) and with hypertension on both visits (confirmed HTN).

All recorded data were analyzed using Statistical Package for Social Sciences version 14.0 (SPSS Inc, Chicago, Ill).

RESULTS

The sample characteristics are presented in *Table I*. The sample included 296 men and 443 women, whose mean (standard deviation) age was 63 (11) and 61 (10) years respectively.

Table I. **Characteristics of the 739 study sample participants.**

Women, n (%)	443 (59.9%)
Age (years), mean (SD)	62 (11)
Education (years), median (IQ)	4 (4 -11)
Body mass index (kg/m2), mean	28.0 (4.4)
Participants under drug treatment	247 (33%)
Left ventricular hypertrophy, n (%)	187 (25.9%)

IQ: interquartile range; SD: standard deviation

The prevalence of hypertension (HTN_1) was 63.4% (95% CI: 59.8-66.9) when using BP measurements from the first visit and 60.2% (56.6-63.8) when using BP measurements from the second visit (HTN_2). If measurements from both visits were used (HTN_{Final}) the estimated hypertension prevalence was 56.3% (52.7-60.0), p (McNemar test) <0.001 between HTN_1 and HTN_{Final}, and between HTN_2 and HTN_{Final}

(*Table II*). The relative overestimation on the first visit corresponds to 12.6% of the true prevalence (taken as HTN_{Final}).

Two hundred and forty-seven individuals were under antihypertensive drug treatment. Excluding subjects under antihypertensive drug treatment and estimating hypertension prevalence based only on BP measurements, the prevalence was 44.9% (40.4-49.4) on the first visit, 40.0% (35.9-44.7) on the second visit and 34.2% (29.9-38.6) if measurements from both visits were used (HTN_{Final}), with p (McNemar test) <0.001 between HTN_1 and HTN_{Final} and between HTN_2 and HTN_{Final}.

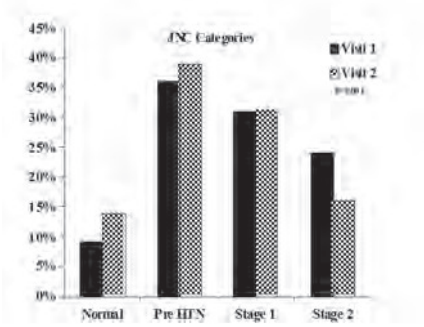

Figure 1. **Comparison of BP categories, according to JNC 7, on the first and second visits, excluding subjects under antihypertensive drug therapy.**

Figure 1 presents the distribution by JNC 7 categories of BP, according to the first evaluation and to the second evaluation, excluding subjects under antihypertensive drug therapy.

On the first visit, the prevalence of stage 1 and stage 2 hypertension was higher than on the second visit (p<0.001, comparing JNC 7 categories between the first and second visits). Among subjects with stage 1 and stage 2 hypertension on the first visit, 32.8% and 11.2% respectively did not fulfil criteria for a diagnosis of hypertension on reassessment (p<0.001, comparing hypertension categories between HTN_1 and HTN_{Final}). On the second visit these proportions were 19.3% and 6.6% respectively (p=0.03, comparing hypertension categories between HTN_2 and HTN_{Final}) (*Figure 2*).

Table II also displays the estimated proportion of awareness, treatment and control according to criteria based on one or two visits. Considering data from two evaluations increased the proportion of awareness and treatment, whereas the proportion of control decreased.

There was a positive association between HTN and male gender, age, BMI and LVH and a negative association with education (*Table III*). BMI was associated with gender and education. Therefore, gender and education were considered possible confounders of the association between BMI and HTN. The magnitude of the associations between overweight/obesity and hypertension according to different definitions (HTN_1, HTN_2 and HTN_{Final}) was similar, and this association was independent of gender and education (*Table IV*).

There was no significant difference between the association of hypertension according to different definitions (HTN_1, HTN_2 and HTN_{Final}) and LVH. This association was independent of age and BMI (*Table V*). When treated individuals were excluded, this association was unchanged.

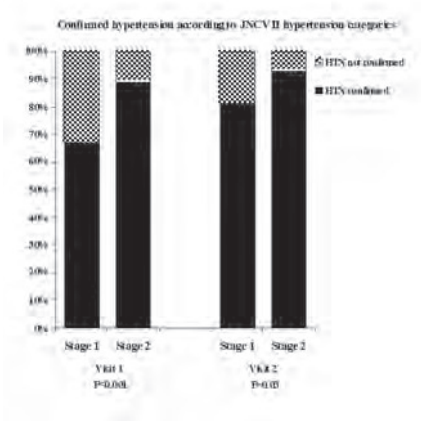

Figure 2 **Comparison of proportion of subjects with confirmed hypertension according to JNC 7 hypertension categories on each individual visit**

Table II. **Comparison of the estimates of hypertension prevalence, awareness, treatment and control according to the different definitions used (HTN_1, HTN_2 and HTN_{Final}).**

	HTN_1	HTN_2	HTN_{Final}	p*	p**
Hypertension	63.4%	60.2%	56.3%	<0.001	<0.001
Awareness	60.2%	60.7%	64.4%	0.02	0.02
Treatment	53.1%	55.5%	59.8%	0.05	0.02
Control	24.9%	37.4%	22.0%	0.03	<0.001

*Comparison between HTN1 and HTNFinal using the McNemar test.
**Comparison between HTN2 and HTNFinal using the McNemar test.

Table III. Crude odds ratios (95% CI) quantifying the association between sociodemographic variables, body mass index (BMI) and left ventricular hypertrophy (LVH) with hypertension according to different definitions (HTN_1, HTN_2 and HTN_{Final}).

	HTN_1	HTN_2	HTN_{Final}
Male	1.40 (1.02-1.91)	1.29 (0.95-1.75)	1.33 (0.95-1.79)
Age (years)	1.07 (1.06-1.09)	1.08 (1.06-1.10)	1.09 (1.06-1.09)
Education (years)	0.92 (0.89-0.95)	0.92 (0.89-0.95)	0.92 (0.89-0.95)
BMI			
<25 kg/m²	1	1	1
25-29.9 kg/m²	1.98 (1.38-2.86)	1.47 (1.03-2.11)	2.01 (1.39-2.89)
≥30 kg/m²	3.57 (2.29-5.51)	2.76 (1.79-4.25)	3.42 (2.23-5.24)
LVH	4.11 (2.68-6.29)	3.91 (2.65-5.86)	4.15 (2.81-6.14)

Table IV. Odds ratios (95% CI) estimating the association between body mass index (BMI) and hypertension according to different definitions (HTN_1, HTN_2 and HTN_{Final}), adjusted for gender and education (years).

	HTN_1	HTN_2	HTN_{Final}
BMI			
<25 kg/m²	1	1	1
25-29.9 kg/m²	1.88 (1.29-2.74)	1.36 (0.94-1.97)	1.89 (1.30-2.75)
≥30 kg/m²	3.40 (2.14-5.40)	2.51 (1.60-3.93)	3.21 (2.06-5.01)
Male gender	1.79 (1.28-2.51)	1.61 (1.17-2.23)	1.68 (1.21-2.31)
Education	0.92 (0.89-0.96)	0.92 (0.89-0.95)	0.92 (0.90-0.98)

Table V. Odds ratios (95% CI) that estimate the association between hypertension by different definitions (HTN_1, HTN_2 and HTN_{Final}) and left ventricular hypertrophy (LVH) adjusted for age (years) and body mass index (BMI).

LVH		LVH		LVH	
HTN_1	2.64 (1.68-4.15)	HTN_2	2.49 (1.62-3.84)	HTN_{Final}	2.71 (1.79-4.11)
BMI	1.06 (1.01-1.20)	BMI	1.06 (1.02-1.10)	BMI	1.06 (1.01-1.10)
Age	1.06 (1.04-1.07)	Age	1.06 (1.04-1.07)	Age	1.06 (1.04-1.07)

Figure 3 depicts the age and gender-adjusted prevalence of LVH in nine groups resulting from cross-classification by BMI and no hypertension, unconfirmed hypertension and confirmed hypertension. LVH was almost nonexistent in normal-weight subjects without hypertension. On the other hand, in subjects with unconfirmed hypertension, LVH prevalence was closer to that of subjects with confirmed hypertension.

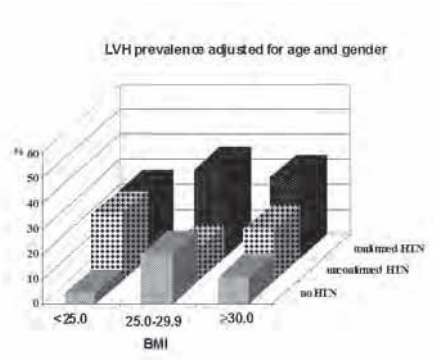

Figure 3 Left ventricular hypertrophy (LVH) prevalence, adjusted for gender and age, by body mass index (BMI) class, in three groups: without hypertension on either visit (no HTN), with hypertension only on the first visit (unconfirmed HTN) and with hypertension on both visits (confirmed HTN).

DISCUSSION

The estimated hypertension prevalence was significantly different when based on BP measurements on the first (HTN_1) or second visit (HTN_2) than based on fulfilling the same criteria of hypertension on both visits (HTN_{Final}). This study adds to previous published studies a quantitative assessment of the magnitude of overestimation, which corresponds to 12.6% of the true hypertension prevalence (taken as HTN_{Final}).

Several studies have been conducted worldwide to estimate the prevalence of hypertension in adult populations[5]. In almost all studies the BP measurement methods included a number of different measurements in just one evaluation, despite the universal consensus on the limitations of this option. The National Health and Nutrition Examination Survey (NHANES) III[5], the Canadian Heart Health Survey (CHHS)[5], the cohort study Incidence of Arterial Hypertension in the Working population Antillo-Guyanaise (INHAPAG)[19] and Arterial Hypertension in Poland Plus Lipid Disorders and Diabetes (NATPOL PLUS)[20] are exceptions. Comparing the prevalence of hypertension between studies from North America (Canada and the USA), in which two visits were used, and Europe (UK, Finland, Spain, Germany, Sweden and Italy), in which one visit was used[21], the mean prevalence in Europe (44.2%) was much higher than in North America (27.6%). Ignoring the difference in hypertension definition criteria

might have caused overestimation of hypertension prevalence in Europe.

In our study, as in others[6-8], the average BP in the second clinic evaluation was lower than in the first. This decline mainly reflects the statistical phenomenon of regression to the mean and the so-called "white-coat" effect. When hypertension is defined as a dichotomous variable, as is usual in estimating hypertension prevalence, the cut-off point for hypertension is higher than the mean BP. Regression to the mean will lead to a reduction in the proportion of individuals above this point, and therefore a reduction in hypertension prevalence. It is unlikely that in our study this decrease is explained by changes in lifestyles by participating in the study, due to the short interval between visits.

Bovet et al.[8], in a study conducted in Dar es Salaam, Tanzania, showed that the BP decrease was large between the first and the second visit but small between additional visits, and concluded that the prevalence of high BP based on repeated readings at a second visit will estimate the true prevalence in the population fairly well. Based on this observation, some authors rely on just the second visit to calculate hypertension prevalence[22] to minimize overestimation. We found, as far as we know for the first time, that the estimate of hypertension prevalence is even lower if the same criteria for a definition of hypertension in two different evaluations are combined than if data only from the second evaluation are used. For a diagnosis of clinically relevant hypertension, as in randomized controlled trials, the usual criteria for hypertension definition involve demonstration that BP elevation persists over several visits, but in community studies, with more than one visit, the definition hypertension is usually based on the mean of the measurements[5,6].

Approximately two thirds of subjects who were considered hypertensive in one evaluation but not confirmed upon reassessment were included in JNC 7 stage 1. As expected, the majority of individuals misclassified as hypertensive were in less severe stages.

When hypertension was defined using BP measurements from two visits, the estimated proportion of awareness and treatment increased, due to the decrease in the denominator. The level of control did not increase as in other studies[7,19], due to different criteria to define hypertension control. When hypertension prevalence was estimated based on two BP evaluations, hypertension control was defined as systolic BP <140 mmHg and diastolic BP <90 mmHg in both evaluations. The results suggest that caution should be used in attributing differences in estimates of prevalence and control of hypertension to regional variation. The various definitions of control in different studies and some confusion regarding the criteria used to identify an individual with hypertension under control make comparisons difficult[6].

The estimated hypertension prevalence was significantly different between definitions but this had no impact on the association between BMI and hypertension or between hypertension and LVH. All the estimates of hypertension prevalence had a strong and independent association with LVH, and we can conclude that a single high BP measurement, although with high variability, may be associated with LVH. Elevated casual BP can be predictive of later hypertension[23] and the positive predictive value of BP estimation is highest in older age groups[24]. LVM and relative wall thickness are more closely related to 24-h ambulatory BP than to casual BP measurement, but white-coat hypertension is also associated with LVM and LVH[25] and should not be considered a benign condition. So, an abnormal high BP measurement, in an individual aged 45 years or older, should be subject to careful follow-up, since LVH is an independent predictive factor of cardiovascular disease and death[26-28].

The combination of obesity and hypertension is more consistently associated with LVH than either stimulus alone[29]. This is clearly demonstrated in *Figure 3*, in which the highest prevalence of LVH is observed among overweight/obese subjects with confirmed hypertension.

This study has two main limitations: intrasubject and interobserver variations that could explain part of the observed difference. First, we cannot exclude the possibility that some of the observed difference is explained simply by the fact that the first visit occurred in the morning and the second in the afternoon. Blood pressure usually follows a reproducible circadian pattern, characterized by low levels during sleep and a rapid increase during the early-morning period (10), but this has a limited reproducibility in the general population as well as across different age and gender subgroups[30].

Moreover, no significant differences have been reported between BP measurements during the morning (after the early-morning period) and in the afternoon. Second, physicians are known to record higher BP values than nurses, medical assistants or technicians[10]. It might be argued that the decline in hypertension prevalence on the second visit shown in this study could have been larger if the same observer had taken blood pressure measurements on both visits. Third, observer error is a major limitation of the auscultatory method. At the time the survey was conducted the mercury sphygmomanometer was regarded as the gold standard for clinical and epidemiological measurement of blood pressure, as aneroid and oscillometric devices had not been accepted as being as accurate as mercury devices. Although the latter have the advantage of easy measurement with a simple device, the discrimination of Korotkoff sounds varies between observers. Other problems with this method include the auditory acuity of the observer, inappropriately rapid cuff deflation rate often seen in busy mass screening and routine medical practice, operator bias for BP values, and digit preference[9].

Our results have major implications regarding study design and the interpretation of estimates of prevalence, awareness, treatment and control of hypertension. Disregarding the white-coat effect, regression to the mean and within-person variability of blood pressure, and relying on few BP measurements, leads to erroneous conclusions about the prevalence and level of awareness, treatment and control of hypertension in the population. From a clinical and epidemiological perspective, substantial intra-individual variability of BP warrants multiple BP readings over several visits. To minimize the difficulties of a strategy based on two separate visits, repeated BP measurements could be obtained in random sub-samples of population under study and appropriate adjustments performed accordingly. Additionally, for correct interpretation of survey results, authors need to provide clearer statements of the definitions employed, as different criteria for the definition of hypertension give different estimates of hypertension prevalence.

CONCLUSION

In conclusion, the prevalence of hypertension based on a single evaluation was overestimated by 12.6%, compared with estimates based on two evaluations. This strongly corroborates the recommendation that BP should be measured in at least two office evaluations both for clinical purposes and in epidemiological studies. Despite the significant difference in prevalence when using different hypertension definitions, this had no impact on the association between BMI and hypertension and between hypertension and LVH. Both had a strong and independent association with hypertension whichever definition was used, which suggests that the apparent overestimation in prevalence may not represent misclassification in populations older than 45 years. A single high BP measurement, in an individual older than 45, was associated with LVH, even if hypertension was not confirmed in a second assessment.

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