What Is the Value of Home Blood Pressure Measurement in Patients with Mild Hypertension?

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SUMMARY To investigate the value of home blood pressure (BP) measurements, the BP was recorded daily by the patient at home and compared with recordings in the physician's office and with a 24-hour BP recording taken with a noninvasive ambulatory BP recorder in a group of 93 patients with mild untreated hypertension. Office BPs (mean 148/94 mm Hg) were higher than either home (138/89 mm Hg) or average 24-hour BPs (131/89 mm Hg). For systolic BP, home and office measurements gave similar correlations with 24-hour BP (0.67 and 0.55). For diastolic BP, however, home readings were lower and more accurate (0.76 vs 0.36). Thus, our findings indicate that home readings reflect the overall level of BP more reliably than office readings, and if due consideration is given to the fact that they are usually lower than office readings, they may be used as an alternative and cost-effective means of evaluating patients with mild hypertension. (Hypertension 6: 574-578, 1984)

KEY WORDS • home blood pressure • 24-hour recorder • mild hypertension • echocardiography

FOR many years, casual blood pressure (BP) measurement taken in the physician's office with a sphygmomanometer has been used as the standard for diagnosing hypertension. However, BP is a constantly changing variable that is influenced by both physiological and psychological stimuli.1 2 The anxiety-provoking experience of an office visit may cause a transient rise in BP, which we have designated white-coat hypertension.1 3 This phenomenon may account for our finding that BP taken in the physician's office at any given time may not be truly representative of the patient's average daily BP, particularly in patients with mild hypertension.

There is an increasing body of evidence that indicates that single casual measurements of BP may be, because of their variability, provide a very unreliable index for the evaluation of hypertension and that measurements made over a more prolonged period of time are preferable.4 Thus, basal BP recordings have been found to be superior to casual BP ones both for predicting long-term BP changes5 and morbidity events.6 The two alternative ways of measuring BP that have been most commonly used are measurements made at home by the patient and measurements by ambulatory blood pressure recorders. Results obtained with the latter have given closer correlation with target organ changes, such as ventricular hypertrophy, than have casual BP measurements.7

BP measurements made by the patient at home have also been used for many years to evaluate hypertension, but it has not been determined whether such readings are more representative of an individual's overall level of pressure than readings taken in the physician's office, although it is well known that home pressures tend to be lower.8-11 The present study was designed to assess the usefulness of home BP measurements in predicting the average 24-hour BP levels of patients with mild untreated hypertension. We compared BPs taken by physicians in their offices with a sphygmomanometer to recordings by patients at home with a sphygmomanometer and to those recorded automatically for 24 hours by an ambulatory noninvasive BP monitor, the Avionics P3 (Del Mar Avionics, Irvine, California). To assess the relationships among the various measures of BP and target-organ changes, echocardiography was used to assess left ventricular hypertrophy.

Methods

We studied 93 patients with documented mild-to-moderate uncomplicated essential hypertension from the Hypertension Center of the New York Hospital-Cornell Medical Center. The group consisted of 74 males and 19 females with a mean age of 42 years (± 15 years) and an age range between 16 and 79 years. Any patient who had been treated with antihyperten-
sive medication (48% of the participants) was taken off therapy at least 2 weeks before the study. The patients' dietary sodium intake varied and was not restricted.

Blood pressures were measured in three ways: 1) in the physician's office with patients in the seated position by the same physician in the Hypertension Center on at least three occasions over a period of about 1 month (at each visit at least three measurements were taken with a standard Baumanometer mercury column and stethoscope and averaged); 2) at home manually by the patient (referred to below as Home Manual readings); and 3) with an automatic monitor over a 24-hour period that included home readings (referred to as Home Automatic readings). The sequence of these procedures was randomized. The patients were supplied with a previously calibrated sphygmomanometer (Bristoline, Inc., Freeport, New York) and a stethoscope and instructed by a nurse in their proper use. The disappearance of any detectable sound (Phase 5 Korotkoff) was recorded as the diastolic blood pressure. After an adequate session of training and practice, patients were instructed to take their blood pressures at home at least twice daily (morning and evening) for 3 weeks. The majority of these readings were taken on a working day. The patients were also fitted with an ambulatory noninvasive automatic BP monitor (Avionics P3) as previously described in detail. The recorder was worn for a 24-hour period on a normal working day when possible. Of the 93 patients, 64 wore the recorder during a normal working day. Blood pressure was recorded automatically every 15 minutes during awake hours and every 30 minutes while asleep. The machine’s readings had been compared simultaneously to those of the standard sphygmomanometer; differences of less than 5 mm Hg for systolic and diastolic BP between the two sets of readings were accepted as accurate. Use of this recorder allowed patients to take part in their normal daily activities, which they recorded in a diary after each blood pressure reading. Analysis of the diary allowed us to identify readings taken at home and those taken at work. When the patients returned to the Hypertension Center the following day, the accuracy of the Avionics P3 was again tested against the mercury column. The accuracy of this recorder has been validated against both mercury sphygmomanometer and intraarterial readings, and it has been found to be equally reliable for both systolic and diastolic pressures.

M-mode echocardiograms were performed with standard procedures, as previously described. End-diastolic relative wall thickness (RWT) was measured as an index of concentric left ventricular hypertrophy.

Statistical Analysis of the Data

Data were analyzed by either Pearson correlation coefficients or analysis of variance. Results are expressed as means ± standard error. Home Manual data were available for 1-week analyses on 93 patients and for 1- and 3-week analyses on 86 patients. Since there were no differences between 1- and 3-week readings, data from all 93 patients were used in all analyses.

Results

Comparison of Home Manual and Office Readings with Average 24-Hour Blood Pressure Levels

The first set of analyses compared BPs taken automatically by the Avionics P3 for 24 hours with those taken manually at home and in the doctor's office. The highest of these three estimates of BP were the office readings (148/94 ± 2/1 mm Hg) and the lowest, the average 24-hour pressures (131/89 ± 1/1 mm Hg). The differences were significant (p < 0.01) for both systolic and diastolic pressures. The Home Manual readings (138/89 ± 2/1 mm Hg) were also lower than the Office pressures (p < 0.01 for both systolic and diastolic pressures). The Home Manual readings (138/89 ± 2/1 mm Hg) were also lower than the Office pressures (p < 0.01 for both systolic and diastolic pressures), but the Home Manual systolic pressures were higher than the average 24-hour pressures (p < 0.01), while the diastolic pressures were similar (p = NS).

For individual patients, the average 24-hour pressures were correlated with average Office pressures and average Home Manual pressures. For systolic pressure (Figure 1) these correlation coefficients were

![Figure 1](http://hyper.ahajournals.org/)

**Figure 1.** Left: Chart (Office) systolic blood pressure vs average 24-hour systolic blood pressure measurements. Right: Home Manual systolic blood pressure vs average 24-hour systolic blood pressure measurements. Lines of identity have been drawn.
very similar \( r = 0.55, p < 0.001 \); and \( r = 0.67, p < 0.001 \), respectively), but for diastolic pressure (Figure 2), the correlation of 24-hour pressure with Home Manual pressure \( r = 0.76, p < 0.001 \) was significantly higher \( (p < 0.05) \) than the Office pressures \( (r = 0.36, p < 0.01) \). It can be seen from Figure 2 that the better correlation with Home Manual diastolic pressures is partly dependent on the results of one patient who had a diastolic pressure of 120 mm Hg at home, 86 mm Hg in the office, and 121 mm Hg over 24 hours. Recalculation of the correlations without this patient's data resulted in \( r \) values of 0.44 for Office pressures vs 24-hour pressures and 0.48 for Home Manual pressures. Although the correlation coefficients were more similar in this case, the original relationship did not change, as Home Manual blood pressures continued to be at least as good, if not better, a predictor of the average 24-hour BPs. Furthermore, there was no a priori justification for omitting this patient's data.

The 24-hour recordings were further analyzed according to the patients' activities during the recording period. The average pressures at work were 139/94 ± 2/1 mm Hg, at home (Home Automatic) 133/89 ± 2/1 mm Hg, and asleep 118/77 ± 2/1 mm Hg. Differences among these three sets of readings were significant \( (p < 0.05) \). We also analyzed the data to determine whether the Home Manual or Office pressures correlated more closely with Work pressures. For systolic pressure, the correlation coefficients were not significantly different \( (r = 0.55, p < 0.001 \text{ for Work vs Home Manual}, \text{and } r = 0.45, p < 0.01 \text{ for Work vs Office}). For diastolic pressure, however, the Home Manual readings once again gave better correlations \( (r = 0.65, p < 0.001 \text{ for Work vs Home Manual and } r = 0.37, p < 0.05 \text{ for Work vs Office}).

Comparison Between Home Manual and Home Automatic Blood Pressures

There were significant correlations between the two sets of home readings: \( r = 0.69 \) for systolic and \( r = 0.71 \) for diastolic pressure \( (p < 0.001) \). The average diastolic pressure taken manually at home was identical to those taken automatically by the Avionics P3 recorder \( (89 ± 1 \text{ mm Hg}) \); but the average Home Manual systolic pressure \( (138 ± 2 \text{ mm Hg}) \) was significantly higher \( (p < 0.05) \) than the average Home Automatic systolic pressure \( (133 ± 2 \text{ mm Hg}) \). Home Manual blood pressures taken during morning hours were \( 138 ± 1/90 ± 2 \text{ mm Hg} \) and during evening hours, \( 140 ± 2/88 ± 1 \text{ mm Hg} \). There was no significant difference between the two. The correlation coefficient relating morning and evening readings was 0.93 for systolic pressure and 0.63 for diastolic \( (p < 0.001 \text{ for both}).

Comparison Between Blood Pressures Recorded Manually at Home During Week 1 and Week 3

We also compared readings taken manually at home during the first week \( (145/91 ± 3/2 \text{ mm Hg}) \) and the third week \( (143/90 ± 3/2 \text{ mm Hg}) \). There was no difference between the two sets of readings and very high correlations \( (r = 0.77 \text{ for systolic and } r = 0.80 \text{ for diastolic pressure}; p < 0.001 \text{ for both}) \). All patients did not record home BP for a 3-week period \( (n = 27) \).

Relationship of Left Ventricular Hypertrophy to Office, Home, and 24-Hour Blood Pressures

In keeping with the generally mild degree of hypertension observed in this study, only 16% of our patients showed measurements of end-diastolic RWT that were more than two standard deviations above the normal mean in this laboratory.\(^13\) The prevalence of left ventricular hypertrophy in this population fell at the lower end of the range of 23% to 47% observed in previous echocardiographic studies of hypertensive patients reported from this laboratory.\(^13,14\)

As might be expected in view of the relatively modest range of variability of BP, only weak and statistically insignificant correlations existed between office blood pressures and RWT (see Table 1). In contrast, closer correlations were observed between 24-hour or Home Manual BPs and RWT. The closest correlation was with Home Manual measurement of systolic BP \( (r = 0.45; p < 0.01) \).
Table 1. Relationship of Blood Pressure Measurements to Right Wall Thickness (RWT) as an Index of Left Ventricular Hypertrophy

<table>
<thead>
<tr>
<th>Type of recording</th>
<th>Correlation coefficients RWT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SBP</td>
</tr>
<tr>
<td>Office</td>
<td>0.22</td>
</tr>
<tr>
<td>Home Manual</td>
<td>0.45*</td>
</tr>
<tr>
<td>24-hour</td>
<td>0.26</td>
</tr>
</tbody>
</table>

SBP = systolic blood pressure; and DBP = diastolic blood pressure. *p < 0.01.

Discussion

The use of home BP readings has become increasingly popular since the report of Ayman and Goldshine in 1940, and a large number of home recorders are now commercially available. Our study confirms that BP levels at home are usually lower than casual office pressures (by 10/5 mm Hg in our patients), but the question as to which reading more closely represents the patient's average BP has not hitherto been answered. Our study and the study of Gould et al. are the first to compare pressures recorded by the patient at home with ambulatory pressures recorded during normal daily activities. We found that the systolic Home Manual pressures were a little higher than the average 24-hour systolic pressures, but the diastolic pressures were the same.

Gould et al. showed that home BPs recorded by the patient agreed reasonably well with intraarterial pressures simultaneously determined. However, they did not address the question considered here, namely, whether clinic or home pressures correlate most closely with 24-hour pressures. For most people, a normal day can be divided into roughly one-third of the time spent at work, one-third at home, and one-third asleep. Our earlier studies and the present one have shown that there are consistent differences in the average BP during these three situations. Home BPs are intermediate between the extremes of work and sleep, while office pressures tend to be similar to pressures recorded at work.

Patients were asked to measure their BPs for 3 weeks, because of the finding of Laughlin et al. that there is an apparent progressive decline in BP over this period. We did not find this in our patients. Measurements made during the 7-day period of each week did not differ from those made during the 7-day period of the previous week. Thus, taking pressures for the longer period did not provide any advantage.

Our data also provide support for the validity of recordings made with noninvasive ambulatory BP recorders outside the clinic situation. While we and others have shown that these recorders can measure BP accurately in a controlled environment (in the majority of patients), it might be questioned whether the same still applies after the patient has gone home. For both systolic and diastolic BPs the highly significant correlations of around 0.7 between readings taken by the patient at home and those by recorders (and being taken on different days) suggest that the recorders do give accurate readings in free-ranging situations. Furthermore, the diastolic readings were the same when taken in the two different ways. We do not know exactly why the systolic pressures were 5 mm Hg higher when taken manually by the patient, but we suspect that this may have been a result of the physical and mental activity associated with inflating the cuff and listening for Korotkoff sounds.

In another study we have found that the 24-hour BP is more closely correlated with the degree of left ventricular hypertrophy than is the office pressure, provided that the 24-hour recording was made on a working day. In the present study, therefore, we also compared the correlations of Home Manual and Office pressures with indices of left ventricular hypertrophy. Similar to our previous findings for Work BP, Home Manual BP correlated better with measurements of left ventricular hypertrophy than Office pressures, but it should be noted that most of the home readings for the present study were taken on a working day. Furthermore, diastolic pressures recorded by the patient at home gave better correlations with those recorded at work than did office readings, but this was not true for systolic pressure. In this context, it is of interest that Laughlin et al. found that a number of subject variables such as age and severity of hypertension correlated with the difference between office and home pressures for diastolic, but not systolic pressure.

A study that is consistent with our findings is one by Ibrahim et al., who related the effects of antihypertensive treatment to office and home BPs and to ECG changes of left ventricular hypertrophy. They found a closer correlation between ECG changes and BP recorded at home than at the office. Thus, BP measurements in an individual's usual setting appear to be more closely related to target organ effects of hypertension as well as to total 24-hour BP than to physician's office BP readings. Another potential advantage of home BP readings is that they may improve patient compliance and may also be a reliable measure of the effects of antihypertensive medication in patients with borderline hypertension. It should be recognized that home readings are consistently lower than office readings, however. This becomes of considerable practical importance when there is a large discrepancy between home and office readings and when a therapeutic decision has to be made.

In the National Ambulatory Medical Care survey of 1975-1976, essential benign hypertension ranked first among all reasons for visiting a physician and accounted for 46 million visits per year. Most of these were follow-up visits for BP checkups. Therefore, our finding that measurement of BP by the patient at home offers a reliable alternative to office measurement has important implications for the delivery of medical care because the wider use of home BP measurements could provide a cost-effective means of reducing the high cost of office visits.
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