Training and Certification of Blood Pressure Observers

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SUMMARY Accurate, reproducible measurements of blood pressure (BP) were central to the goals and objectives of the Hypertension Detection and Follow-Up Program (HDFP), a multicenter clinical trial on the efficacy of pharmacological treatment of individuals with elevated BP. All potential BP observers with or without previous experience in measuring BP were required to undergo a defined training program and meet set performance criteria to be certified to take HDFP BP. Recertification was required twice a year. Originally an audiotape test was used to measure accuracy of BP readings. This approach was later replaced by a videotape test, which proved more realistic and an equally effective tool for long-term quality control. With this technique of certifications, 75% of the individuals taking the test passed on the first attempt and more than 95% passed with one or two attempts. Although agreement for blinded BP duplicates was generally good, the appearance of sound (systolic BP) was identified with greater reproducibility than was the disappearance (diastolic BP). These recertification procedures were of great value in assuring the continued high quality of our BP data. (Hypertension 5: 610-614, 1983)

KEY WORDS  • blood pressure measurement • multicenter clinical trials • quality control

BLOOD pressure readings of high quality are fundamental to any sound program of detection and follow-up of hypertensives. Yet many factors regarding the participant, observer, equipment, and circumstances of measurement can work against the attainment of this basic objective. In 1972 investigators in the Hypertension Detection and Follow-Up Program (HDFP) focused attention on the need to develop well-standardized blood pressure measurement procedures and an appropriate training program. Such procedures were to be used to screen more than 159,000 men and women in 14 centers around the United States, usually in their homes. Ultimately nearly 11,000 hypertensives would be entered into a long-term program, involving several years of follow-up in scheduled visits both in the home and in the clinic.1-3 The 14 Clinical Centers were to follow a common protocol and to pool all data at the Coordinating Center for entry into the computer files for periodic analysis. The program was designed to test the reduction in mortality achievable through a special management plan ("Stepped Care") as compared with existing community care after referral from the screening phase ("Referred Care").

Methodology of Blood Pressure Measurement

For the HDFP, review of published guidelines such as those of the American Heart Association4 was of substantial assistance, but few established blood pressure measurement training programs were in existence in 1972. The advent of newer measurement devices and the responsibility to assure optimum choice among currently available techniques led to further inquiry and pilot evaluation of alternative devices.5 The decision was reached to use both the conventional mercury sphygmomanometer and the random-zero device.

A series of procedural steps were developed and elaborated in detail in the HDFP Manual for Training and Certification of Observers.6* The participant was
to be seated quietly for at least 5 minutes, without smoking, before the first measurement was taken. Just prior to the first measurement, the peak inflation level for all readings at this visit was determined by the addition of 30 mm Hg to the pressure at which the palpated radial pulse was obliterated on preliminary inflation of the blood pressure cuff. Blood pressure readings were always taken on the right arm with a minimum 30-second interval between readings. For each reading, the cuff was inflated to the predetermined peak inflation level and then deflated at a constant rate of 2 mm Hg/sec to a point 10 mm Hg below the level of the diastolic reading. The systolic reading was taken as the level of pressure when the first Korotkoff sound was heard. The diastolic reading was taken as the level of pressure when the last such sound was heard.

A program of training and certification for all staff members responsible for recording blood pressure readings was developed that addressed procedures to both standard and random-zero sphygmomanometers. It was designed to quantify the trainee’s level and attainment of the required standard of performance. Recertification was required at semiannual intervals for the duration of an observer’s service in the program.

The number of Clinical Centers participating, the size of the field staffs needed for the extensive community screening effort, the need for recertification, and the occurrence of personnel turnover that necessitated new training throughout the program were all important factors. A two-stage training strategy was adopted. For the first stage, training supervisors from all Clinical Centers met in Houston in January, 1973, where the full training program was presented, and the supervisors were themselves certified as HDFP blood pressure observers. Each supervisor was then provided with the full set of training materials needed to carry out the second stage, reproducing exactly the same program for the field and clinic staff of his or her own Clinical Center. The Coordinating Center received from the Clinical Centers documentation of each qualifying observer’s training performance and updated this file semiannually when recertification — always carried out locally — was done. This scheme established good cooperation between the Coordinating Center, which was responsible for overall monitoring and quality control, and the Clinical Centers.

There were four components of the original training system:

1. Lectures with accompanying slides on the rationale and the methods adopted by the HDFP for blood pressure measurement
2. A 16 mm film containing blood pressure sequences for demonstration of Korotkoff sounds with changing manometer readings
3. Live practice and testing
4. An audiocassette system for practice and testing.

The central component of the quantitative assessment of observer performance was, at the outset, the audio-cassette system described by Rose. This system was based on tape-recorded sequences of Korotkoff sounds which were “read” by the trainee through the use of stop-watches. These were started at an audible time signal and stopped when the systolic and diastolic endpoints, as specially defined, were recognized. Because the actual changes in pressure as the sounds were originally recorded were approximately constant at 2 mm Hg/sec, errors in the observer’s recorded stopwatch readings could be interpreted correspondingly. As a standard of performance, the mean time values for each of the series of 12 systolic and 12 diastolic readings must be in agreement with the correct time value ± 1 second — corresponding to an allowable range of ± 2 mm Hg. In addition, to insure correct measurement technique, supervised live practice readings were conducted. Split stethoscope observations were also introduced, primarily to verify that the appropriate manual technique was employed.

Over the course of several recertification cycles, some training supervisors urged modification of the test procedure. The audio-cassette method, after repeated use, was regarded as unduly tedious and artificial, in contrast to a more realistic method such as the demonstration film developed by Wilcox. It was also argued that the test sequences had in a sense become “learned” and that the original audio-cassette might be decreasing in value over time as an independent test device. It should be noted that this concern, if valid, does not detract from the usefulness of this procedure for initial training, for which it was originally intended by Rose.

In response to these impressions, the HDFP Coordinating Center undertook to develop a new sound film standard for use in both training of new observers and recertification of those continuing with the program. As with the original material, the approach was based upon decentralization of the training and recertification procedures, with copies to be provided to all centers. Data were transmitted to the Coordinating Center for analysis and for verification of measurement performance, based on the film. Considerations of cost and convenience in the setting of the HDFP led to the choice of videotape as the medium for distribution of this new training aid.

Use of the videotape method in the latter recertification cycles of the HDFP appeared to meet satisfactorily the concerns expressed earlier. The videotape test which replaced the audio test consisted of 12 sequences of actual blood pressure recordings in which the mercury in a standard sphygmomanometer was seen to fall at a rate of 2 mm Hg/sec while the Korotkoff sounds were being heard. The observer was required to record the level of mercury in the column corresponding to the systolic and diastolic pressures. Unknown to the trainee, eight of the 12 sequences actually consisted of four pairs of sequences that had been duplicated. This was done as a means of testing within-observer reliability.

Observers’ measurements were compared to a set of standard readings derived from the mean scores of
“expert” readers (veteran HDFP observers with repeated recertification) who carefully reviewed the tapes. For each of the four paired readings, an average of the two readings was taken as that individual’s most representative measurement for that sequence. An overall mean and variance were then calculated based on seven readings (one of the eight original videotape sequences was not used in scoring due to its demonstration of technical problems making accurate readings difficult), the four averages of the pairs plus the unique readings. In addition, the differences between the paired readings were computed.

The criteria for passing the videotape test were:

1. The overall systolic and diastolic mean must lie within ±1.96 standard deviations from the standard mean. (This criterion detects consistent bias in blood pressure readings.)

2. No more than one systolic or diastolic pair difference may lie beyond ±1.96 standard deviations from the expected zero value. (This criterion tests the repeatability of blood pressure readings.)

Several hundred individuals were hired and trained during the course of the HDFP to measure blood pressures on program participants. Their backgrounds varied, in that some observers were trained health professionals while others had had no experience in the health care field.

Most in 1973 were between 18 and 59 years of age, with two-thirds of the observers being between 20 to 49 years of age; 60% were white women, 24% were white men, 12% were black women, and 4% black men. Corresponding distributions for the 131 observers passing the videotape test in 1979 showed that there were fewer younger individuals, white men and black men, and proportionately more black women; the age distributions were similar.

As previously stated, all HDFP blood pressure observers were recertified approximately every 6 months during the 5-year follow-up phase of the program. During the early part of this phase, the recertification technique essentially repeated the initial training, but, as described, it underwent modification through the years. The last recertification cycle during the clinical trial phase of HDFP was begun in November, 1978, and was completed by May, 1979. The data presented here to illustrate the HDFP experience will refer only to the initial round of certification and final round of recertification. Testing during the initial recertification was done with the audiotape and during the final recertification with the videotape produced by the Coordinating Center of the HDFP.

Results of the Training

Figure 1 shows the distribution of mean differences between the observed mean systolic blood pressures and the correct mean systolic blood pressures or mean errors, in the 582 passed audio tests at baseline and the 131 passed videotape tests at the end of training. The preponderance of negative values seen with the audio tests indicates that most of those individuals who passed were obtaining values slightly below the correct values. In contrast, the results for videotape tests in 1979 showed a more nearly normal distribution, which indicates that on average the individuals passing this test did so with values more representative of the correct values than did the individuals who took the audio test.

The distributions of mean errors for diastolic blood pressures (fig. 2) were similar for the two procedures, although the tendency toward negative values with the audio tests was not as noticeable as was found for systolic readings. It should be kept in mind that these are truncated distributions since they include only those individuals who passed the tests.

Table 1 shows the distributions of the means of differences between the four paired blood pressure sequences represented in the videotape. These differences were generally small, with 70% of observers for systolic blood pressure and 57% for diastolic blood pressure showing essentially no differences between these paired readings. These data, as well as data from the individual blood pressure pairs, showed generally better agreement for the appearance of sound (systolic blood pressure) than for the disappearance of sound (diastolic blood pressure).

![Figure 1. Distribution of mean observer error on passed tests for systolic blood pressure.](http://hyper.ahajournals.org/doi/fig/10.1161/01.HYP.5.4.612)
TABLE 1. Videotape Test: Distributions of Systolic and Diastolic Blood Pressure Mean Pair Differences

<table>
<thead>
<tr>
<th>Mean pair differences (mm Hg)</th>
<th>Diastolic BP readings</th>
<th>Systolic BP readings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>≥6</td>
<td>8</td>
<td>1.6</td>
</tr>
<tr>
<td>−4</td>
<td>11</td>
<td>2.1</td>
</tr>
<tr>
<td>−2</td>
<td>96</td>
<td>18.3</td>
</tr>
<tr>
<td>0</td>
<td>301</td>
<td>57.4</td>
</tr>
<tr>
<td>2</td>
<td>78</td>
<td>14.9</td>
</tr>
<tr>
<td>4</td>
<td>13</td>
<td>2.5</td>
</tr>
<tr>
<td>≥6</td>
<td>17</td>
<td>3.3</td>
</tr>
</tbody>
</table>

TABLE 2. Number of Attempts Required to Pass Videotape Recertification Test

<table>
<thead>
<tr>
<th>Observers</th>
<th>Number of attempts</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>100</td>
</tr>
<tr>
<td>%</td>
<td>76.34</td>
</tr>
</tbody>
</table>

As shown in Table 2, more than 75% of the trainees taking the videotape test in 1979 passed on the first attempt, and two attempts were sufficient for more than 95% of this group. A small number of individuals were not able to pass the test and are not included in this table.

Discussion

Although guidelines for measuring blood pressure had been published by the American Heart Association4 and others prior to 1973, few formal programs other than that developed by Rose7 for training blood pressure observers existed prior to the development of the HDFP training program. Since that time a number of such programs have been developed. Most of them are aimed primarily at the health professional. These include programs of the Heart Associations of Chicago,9 Maryland,10 Wisconsin,11 Connecticut,12 Georgia;13 the Ohio State Health Department;14 the Indiana University School of Nursing;15 the Narco Blood Pressure Teacher;16 the Merck, Sharp and Dohme Company;17 Fletcher;18 and the audio systems developed by Prineas.19 Programs from the Texas Affiliate of the American Heart Association20 and the American Red Cross;21 and parts of the Indiana program,15 are designed for use by both professionals and lay individuals. Other less developed programs and various other films and printed materials in support of training programs are also available.22 The HDFP training film is one of the few with a series of blood pressure readings and corresponding sounds for testing and practice purposes. The Indiana University film15 does provide such a series distributed throughout one of their videotapes. A film by Fletcher18 also contains five such readings. Apparently no other low-cost high-quality films depicting mercury sphygmomanometer readings such as would be preferable in most research and many clinical settings are currently available. In addition, given the current interest in blood pressure in children, there is a surprising lack of material on blood pressure measurement in this age group where different knowledge and techniques may be needed.

There are no readily available materials other than that of the HDFP intended specifically for use in research settings, or for the use of the random-zero sphygmomanometer. It is important to recognize that, while few clinical decisions are likely to be affected by a single blood pressure change of 2 mm Hg, in the research setting where persons may be classified as hypertensive on the basis of a single reading or group of readings, a systematic blood pressure difference of even 2 mm Hg can be important. In the HDFP home screening of over 159,000 persons, if the reading had been consistently 2 mm Hg high and 90 mm Hg was used as an arbitrary cutpoint for blood pressure elevation, over 9000 individuals would have been misclassified as being above that cutpoint. On the other hand, errors of similar magnitude that were not systematic (i.e., readings may be either higher or lower than the true reading) would result in the same number of individuals being classified as hypertensive but with increased random misclassification which would decrease the ability to detect the true relationship of
blood pressure with other factors (e.g., treatment).

During the course of the HDFP it was apparent that constant attention to training was necessary to maintain the strict standards needed for a research program. In addition to the formal local recertification, site visits with direct observation of measurement technique, central recertification sessions, and central monitoring of digit preference were utilized to monitor blood pressure measurement procedures. Such central monitoring served to insure that standardized high-quality blood pressure measurement continued, despite local changes in personnel. Although continued effort has been required on the part of both the blood pressure observers and those maintaining the recertification and training system, it was felt that no alternative mechanism would suffice for maintaining the quality of the blood pressure data.

We have described a blood pressure measurement training and recertification system which has, over the last 7 years, been continuously in use to assure that a large group of persons with varied backgrounds in centers throughout the country acquire and maintain standardized knowledge and skills regarding the measurement of blood pressure. The tools evolved over the course of the program have continued to work well and have insured high-quality blood pressure data throughout the trial.

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