Behavioral Treatment of High Blood Pressure II. Acute and Sustained Effects of Relaxation and Systolic Blood Pressure Biofeedback

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The effects on blood pressure of regular patient and professional monitoring of blood pressure, extensive patient-involved assessment of results, relaxation, and systolic blood pressure biofeedback are analyzed by comparisons of data from two 3-month treatment periods with results from a 1-month baseline period and by comparisons among control and treatment groups. Ninety borderline hypertensive patients completed the treatments. Major findings are: A. Acute effects; 1) Both relaxation and systolic blood pressure biofeedback lowered blood pressure acutely. 2) Improvement in performance of relaxation and biofeedback with practice showed that they are learned skills. 3) Acutely, relaxation and biofeedback were equally effective for lowering systolic blood pressure, but relaxation lowered diastolic blood pressure more. B. Long-term effects; 1) Blood pressure declined for at least 6 months with regular monitoring and patient-involved assessment. 2) The greatest lowering of blood pressure by behavioral intervention occurred during periods when pressures tended to be highest. 3) A combination of relaxation and biofeedback, with biofeedback preceding relaxation, was better than either used alone and slightly, but not significantly, better than relaxation preceding biofeedback. 4) The long-term effects of biofeedback were slightly greater than those of relaxation. A staged, incremental behavioral treatment of borderline hypertension is proposed.

This is the second in a series of reports dealing with the evaluation of systolic blood pressure (SBP) biofeedback (F) and relaxation (R) for the control of high blood pressure (HBP). Our first report (1) described the findings from a 1-month baseline study of 127 patients diagnosed as having borderline HBP. This paper describes the results obtained during a 6-month controlled study of F and R. It uses the extensive, self-determined baseline data as bases for determining the responses to treatment and addresses the following questions: 1) Does R or F provide a significant reduction in BP relative to a control condition? 2) Is a combination of R and F more effective than either treatment alone? 3) Is the benefit obtained dependent on the order in which R and F are used? 4) Is either treatment more effective than the other? and 5) Is there any relationship between the effectiveness of behavioral treatment and the clinical status of the patient as indicated by the presence or absence of diuretic therapy?

Several review articles (2–5) concluded that R and F produce comparable effects on BP; that these effects are small but reliable; and that there is insufficient data available to determine whether one behavioral treatment is better than the other, or if either produces clinically sig-

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Received for publication April 13, 1981, revision received August 11, 1981.

0033-3174/82/020155+16$02.75

nificant effects. Despite the lack of strong comparative data, most reviewers recommend the use of R since it requires no equipment and is inexpensive. However, further investigation is warranted because of evidence that suggests that the two methods affect BP through different mechanisms. For example, studies of R (6–8) have shown that it is associated with equivalent reductions in SBP and diastolic blood pressure (DBP), with reductions in breathing rate, heart rate, and oxygen consumption, suggesting that R affects BP primarily by reducing cardiac output. Kristt and Engel (9) have suggested that F primarily affects peripheral resistance because when their patients with mild to moderate HBP learned to raise and to lower SBP using F, no concomitant changes in muscle tension (triceps brachii), EEG (alpha wave activity), heart rate, or breathing rate were observed. Furthermore, Messerli et al. (10), using DPB F after the method of Elder et al. (11), found acute changes in HR during DBP modulation but long-term reductions in peripheral resistance derived from direct measurements of stroke index and cardiac output. They concluded that their findings supported those of Kristt and Engel since they saw no long-term changes in heart rate or stroke index whereas DBP and peripheral resistance fell. Therefore, the current study seeks to elucidate further these suggested differences between R and F by investigating their effectiveness, individually and in combination, in the treatment of borderline HBP.

MATERIALS AND METHODS

Subjects

A group of 90 volunteer patients completed this study. All patients were drawn from the original sample of 127 subjects who completed the baseline phase of the program (1). Thirty-seven patients withdrew from the project before its completion. Of those who continued, 46 patients were receiving no medication and 44 were receiving only diuretic antihypertensive therapy. All patients being treated with any other antihypertensive medication, or taking a beta-blocker for any reason, were excluded from the study. Since a detailed description of our selection criteria was reported earlier (1), it will not be repeated here.

Experimental Design

Figure 1 outlines the study design. This report describes findings from the two 3-month treatment phases only. All patients who completed the baseline phase of the study were assigned to one of three treatment groups: 1) A control group (C), 2) an F group, 3) an R group. Group assignments were made to provide approximately equal numbers of diuretic-treated and unmedicated patients in each subgroup, as well as equivalent average baseline BPs. Each of the three treatment groups then began a 3-month treatment phase during which all patients were seen monthly by one of the investigators in the outpatient clinic of the Columbia Medical Plan (CMP). On completion of this treatment phase, patients in the R and F groups were subdivided into groups matched according to average BP levels within the respective groups. These subgroups then either continued with their original behavioral treatment or changed to the opposite treatment. Thus there ultimately were five treatment groups: CC, RR, RF, FF, and FR, where the letters identify the first and second 3-month treatments, respectively. In each of the five groups, about half were receiving diuretic therapy for their HBP and half were untreated. Each patient continued to be seen by the same investigator in the outpatient clinic once monthly.

The following points should be emphasized: 1) No patient (nor investigator) knew the group assignment of a patient until shortly before that assignment was made: 2) All patients were informed at the time they first entered the study (the beginning of the baseline phase) that they could not be told their eventual group assignments and that 20% of the volunteers were to serve as controls by continuing to monitor BP for 6 months beyond baseline, but that even monitoring alone could be an effective way to lower BP. They were also told that all patients who completed the study could enroll in any part of behavioral treatment program that they had missed

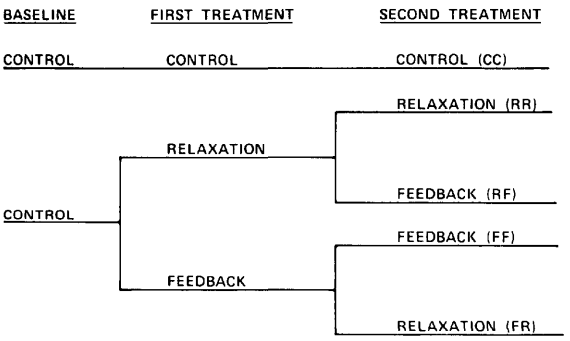

Fig. 1. Study design: 1-month baseline and two 3-month treatment phases.

because of the study design on completion of the second treatment phase. Thus control patients learned that they were to serve as control patients only at the time when group assignments were made for the first treatment phase. They also were told that after 6 months as a control patient they could receive 6 months of behavioral treatment: 3) On completion of the second treatment phase, patients enrolled into other groups as appropriate—for example, RR patients were offered F; RF or FR patients entered into a follow-up phase. Data from these stages of the study will be reported later.

Measurements: Apparatus

At the start of the baseline phase, each patient was given a sphygmomanometer (Propper Autosfig®, Propper Manufacturing Company, Garden City, NY) and careful instruction in its use for self-determination of BP. Instructions were to measure and record one's own BP three times consecutively each morning (on awakening), three times consecutively during the afternoon (between 11:30 A.M. and 4:00 P.M.), and three times consecutively in the evening (shortly before retiring). Patients were instructed to use disappearance of sound (Phase V) for DBP. Each patient was given franked envelopes and told to mail the BP log to us daily. Each also was told to obtain a weekly BP determination either by a health professional in the outpatient department of the CMP clinic or by a health professional at the worksite who also used Phase V for DBP. Self-determined and professionally determined BPs were taken from the patient's nonpreferred arm using the patient's assigned manometer—or a mercury-filled manometer if the cooperating health professional preferred this for professional determinations. A normal adult-size arm cuff was adequate for all determinations. When a patient was seen by one of the investigators for a regular monthly visit, the manometer currently in use was exchanged for a newly calibrated one. Thus all aneroid BP manometers were maintained within ± 2% agreement with a mercury-filled manometer (1).

At the end of the baseline phase, each patient was seen at the CMP clinic by one of the investigators and the blood pressure history for that month was reviewed. Data were presented to the patient in graphic form such that the separate lines for morning, afternoon, evening, and professionally recorded BPs could be examined. These graphs were discussed in detail with special attention to such features as time-of-day effects, workday and weekend differences, self-determined and professionally determined differences, and adaptation trends such as unusually high or low values, days, or periods. Patients were encouraged to ask questions about the data or about various aspects of BP or HBP. They often were surprised by the variability of BP; many commented on the unreliability of a single reading.

Behavioral Treatments

During the interview following the baseline phase, each patient was given a group assignment and instructions for the technique to be practiced during the first treatment phase.

Control Patients. These patients were told to con-

tinue to monitor BP and to mail their data to us daily as they had done in the baseline phase. They were seen once monthly throughout the ensuing 6 months, at which times their BP graphs were reviewed as described earlier and their manometers were exchanged. They were encouraged to attend to their BP variations throughout the monitoring period, but strong expectation of BP reduction was not suggested.

Biofeedback Patients. These patients were trained in the clinic to use their sphygmomanometer as an F instrument following the Kristt and Engel (9) modification of the Tursky et al. (12) technique. In this procedure, the patient is trained to inflate the BP cuff to about systolic pressure and to try to inhibit brachial artery sounds. Patients were instructed to attempt to control brachial artery sounds for about 25–30 sec, after which they were to deflate the cuff for about 15 sec. If successful in inhibiting 25% of sounds on the previous trial, the patient was told to inflate the cuff to a pressure level 2 mm Hg less than that of the previous trial. This procedure was repeated until the patient could no longer lower SBP on two consecutive trials. The form on which the patient recorded daily data included spaces for the usual morning, afternoon, and evening values; spaces for recording the SBP at each F trial; and spaces for recording three consecutive values of SBP and DBP immediately on completion of the trial. Patients were urged to practice F several times daily, but were especially encouraged to practice at the time of day when their pressures were likely to be highest as indicated by the findings during baseline. For most patients, this was the afternoon. Patients were seen monthly during this treatment period. Initially they were instructed to develop the F skill through regular practice. Then, during the second treatment month, they were encouraged to develop "a sense of the F response"—that is, they were told to try to identify internal subjective cues that correlated with successful SBP lowering. During the third treatment month, patients were encouraged to practice their skill both formally (using the procedure outlined earlier) and informally without the sphygmomanometer. In this generalization procedure, they were told to use various environmental cues—for example, traffic signals or work breaks—as indicants for brief SBP lowering sessions, during which they were to focus for no more than 30 sec on those subjective cues that were associated with SBP lowering. This was to be done as frequently as possible each day. At each monthly meeting, the patient was given a set of mimeographed pages describing all new instructions for that month.

Relaxation Patients. These patients were instructed in the clinic to use both progressive and meditative relaxation procedures. The progressive relaxation procedure was used primarily to enable the patients to develop a sense of tension. Instructions were given to tense and relax arm, neck, and facial muscles with particular emphasis on noting the different sensations during tensing and relaxing. Then the patients were instructed to focus on one particular muscle or muscle group that was especially tense, to concentrate on that muscle group, and to let it relax. Patients were told that the salient muscle could be different on different occasions, but that within a session only one muscle group should be chosen. Patients were encouraged to relax for about 10 min per session and to practice R at those times of day when their pressures were likely to be highest. The forms used by these patients required that they record BP daily during the morning, afternoon, and evening and that they take three consecutive samples of BP immediately after the R practice. During the first month of treatment, patients were encouraged to develop the R skill; during the second month, they were encouraged to continue practicing but also to develop a sense of the "feeling of relaxation." Finally, during the last month, they were encouraged to generalize their skill using salient environmental cues similar to those described for the F condition. Thus the instructions to R and F patients were structurally similar but the skills taught were different. R patients also were given appropriate mimeographed instructions each month.

Second Treatment Phase. Control patients were seen monthly as in the first treatment phase. Patients who continued the same procedure they had learned in the first phase (the RR and FF groups) were seen monthly to review their results, to exchange manometers, and to discuss whatever events of the past month were relevant. Patients in the reversal groups (RF and FR) were trained and treated as described previously. They were encouraged to focus on the new procedure and to try to develop that skill also. Patients were told not to forget their prior training since that seemed neither feasible nor clinically appropriate, but their practice of it was, from then on, ad libitum.

Statistical Analysis

Several statistical procedures were used. The BMDP (1979 revision) statistical package of the NIH was used for standard *t*-tests and analyses of variance as reported in the results. To test the long-term

TABLE 1. Analysis of Variance Model Used to Evaluate Long-term Treatment Effects

Source	*df*	Notes
I. Level		
A. Overall	1	
B. Between groups	4	
1. Treatment vs. controls	1	
2. Among treatments	3	
C. Within groups	$n - 5$	Error term for level comparisons
II. Regression		
A. Overall	1	
B. Between groups	4	
1. Treated vs control	1	
2. Among treatments	3	
C. Within groups	$n - 5$	Error term for regression comparisons
D. Nonlinear	3	
III. Residual	$3(n - 1)$	Error term for overall and Non-linear regression comparisons
IV. Total	5N	

effects of treatment, a model was developed[1] (Table 1), which enabled us to test group differences in overall BP levels as well as trends throughout the three phases (baseline, and first and second phases). Specific between group comparisons were made using Waller and Duncan's (13) *k*-ratio *t*-test. Brant and Duncan's (14) variation of this procedure was used for comparing treatments with controls. Because BP trends were nonlinear, analyses were performed on log transforms of the data.

RESULTS

Study Participants

Comparison of Patients Who Completed the Study with Those Who Withdrew. Prebaseline and baseline characteristics for the 127 patients who completed the 35-day baseline period have been reported previously (1). Of these, 31 failed to complete the first 3-month treatment phase and six who completed the first treatment phase failed to complete the second. None of the withdrawals were from the control group. The proportions of men to women, medicated to nonmedicated, and white to nonwhite did not differ between the group of patients who completed the study and those who withdrew. The groups also did not differ in age, weight, height, body mass, or prebaseline clinical SBP or DBP. The group who withdrew differed only in that during the baseline period they had somewhat lower average DBP as determined professionally (88.2 mm Hg vs 90.5 mm Hg; t (126) = 1.93; $p < 0.10$) and lower average self-determined DBP throughout the day (88.1 mm Hg vs 91.3 mm Hg; F (1,125) = 5.52; $p < 0.05$).

The following were reasons for withdrawal: "Too busy" or failed to submit data regularly ($N = 21$), change of medication to an antihypertensive drug other than a diuretic ($N = 2$), loss of incentive due to low blood pressure ($N = 9$), fear of

[1]The authors are grateful to Dr. L. J. Brant for his valuable contribution to the development of this statistical model.

monitoring blood pressure ($N = 3$), arm discomfort related to BP measurements ($N = 1$), left the area on an extensive business trip ($N = 1$).

Comparisons of Behaviorally Treated Patients with Controls. During the prebaseline and baseline period, the 20 control patients differed from the 70 behaviorally treated patients in that they had: 1) lower average prebaseline clinical SBP [137.2 mm Hg vs 142.8 mm Hg; t (88) = 2.19, $p < 0.05$] and 2) higher average afternoon [95.0 mm Hg vs 91.6 mm Hg; F (1/88) = 4.08, $p < 0.05$] and evening [93.0 mm Hg vs 89.4 mm Hg; F (1/88) = 4.86, $p < 0.05$] self-determined DBP during the baseline. Also, in the nonmedicated subgroup, control patients had higher baseline evening DBPs than did treated patients [94.2 mm Hg vs 90.0 mm Hg; t (44) = 2.06, $p < 0.05$]. No other effects were significant in comparisons of behaviorally treated patients with controls in the medicated subgroup: t (42) = 1.97 for prebaseline SBP, $t(42) = 1.05$ for baseline afternoon DBP, $t(42) = 1.16$ for baseline evening DBP; or the nonmedicated subgroups: $t(44) = 1.13$ for prebaseline SBP and $t(44) = 1.89$ for baseline afternoon DBP.

Compliance with the Treatment Protocol. The average number of times either R or F was practiced per 35-day period for all groups was 38.4, 38.9, 37.3, and 35.2 during the first and last 35 days of the first and second treatment phases, respectively. No significant group, phase, or group × phase effects were present among the four behavioral treatment groups (RR, RF, FR, and FF). It is noteworthy that both repeating groups (FF and RR) tended to decrease the average number of daily practice sessions across phases, whereas the groups that changed treatments during the second treatment phase exhibited different patterns of compliance. Those patients who changed from R to F tended to increase the rate of practice through the first 35 days of the second treatment phase before decreasing late in the phase, whereas those who changed from F to R tended to increase the rate of practice throughout the last treatment phase. None of these trends was statistically significant.

Acute Lowering of BP (Average BP Immediately After Practice of R or F Minus Average BP Immediately Before Practice of R or F). Figure 2A shows average changes in SBP and DBP immediately associated with the practice of R or F for each of the four behavioral treatment groups. Figures 2B and 2C, respectively, show these changes for the medicated and nonmedicated subgroups. Each quartet of bars shows the average BP response during the four 35-day measurement periods. These acute BP changes were significantly different from zero ($p < 0.01$) across all behavioral groups for the combined group, $F(1/57) = 287.66$ for SBP, $F(1/57) = 79.89$ for DBP; the medicated subgroup, $F(1/26) = 82.81$ for SBP, $F(1/26) = 26.13$ for DBP; and the nonmedicated subgroup, $F(1/27) = 261.22$ for SBP, $F(1/27) = 57.78$ for DBP. Furthermore, the improvement in performance by this measure, between the first 35 days of the first treatment phase and the last 35 days of the second treatment phase also was significant for the medicated subgroup, $F(3/78) = 3.79$, $p < 0.05$ for SBP, $F(3/78) = 3.94$, $p < 0.05$ for DBP; and for SBP of the combined group, $F(3/171) = 4.09$, $p < 0.01$; but only marginal for DBP of the combined group, $F(3/171) = 2.59$, $p < 0.10$. The nonmedicated subgroup did not sig-

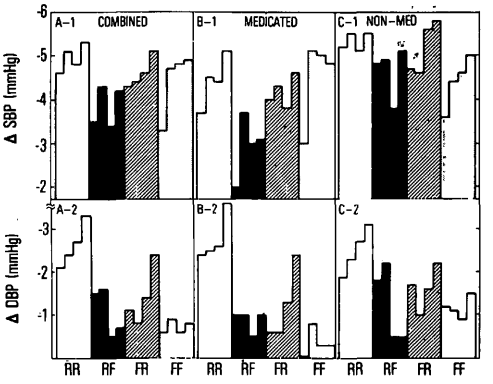

Fig. 2. Acute changes in SBP or DBP with R or F. Each quartet of bars shows average before/after changes in SBP or DBP during the first and last 35 days of each treatment phase. Negative changes indicate reduction in BP.

nificantly improve acute lowering of either SBP, $F(3/81) = 1.26$, or DBP, $F(3/81) = 0.46$, with continued practice. Behavioral group differences in acute BP lowering were significant for DBP in the combined group (Figure 2A-2), $F(3/57) = 6.19$, $p < 0.01$; and the medicated subgroup (Figure 2B-2), $F(3/26) = 3.74$, $p < 0.05$, but not in the nonmedicated subgroup (Figure 2C-2), $F(3/27) = 2.18$. The RR and FR groups showed superior improvement in performance with continued practice whenever group differences occurred; $p < 0.05$, Waller and Duncan (13).

The acute BP changes resulting from R during the first treatment phase (Figures 2A, first two bars for RR and RF groups) increased for both SBP and DBP. This pattern continued through the second treatment phase for those patients who continued with the practice of R (RR group, all four bars). Similarly, F caused a progressive improvement in acute SBP reduction (Figure 2A-1, first two bars for FR group, all four bars for FF group), but was not associated with increased lowering of DBP acutely during either the first (Figure 2A-2, first two bars, FR and FF groups) or the second treatment period (Figure 2A-2, all four bars, FF group). For acute SBP lowering, R and F were equally effective during the first treatment phase, and both treatments were associated with significant improvement from the beginning to the end of that phase, $F(1/73) = 8.53$, $p < 0.01$. The effect of R on acute DBP change during the same period was greater than that of F; $F(1/73) = 12.75$, $p < 0.01$.

Further evidence that F was not associated with acute lowering of DBP is shown by the results of those groups that changed behavioral treatments for the second treatment phase. The RF group regressed in acute DBP lowering when they began to practice F (Figure 2A-2, last two bars of RF group), and the FR group

began to lower DBP only after switching to R (Figure 2A-2, last two bars, FR group). The group × time interactions were significant for DBP in the combined group, $F(9/171) = 3.06$, $p < 0.01$, and the medicated subgroup, $F(9/78) = 2.01$, $p < 0.05$. The FF group never showed a level of acute DBP reduction comparable to that of patients practicing R. Noteworthy also is the drop in acute SBP change that occurred for the RF group when they switched to F (Figure 2A-1, second and third bars for RF group). After practicing F, the degree to which this group lowered SBP was increased (Figure 2A-1, third and fourth SBP bars, RF group).

For the nonmedicated patients during the first treatment phase (Figures 2C, first two bars for each treatment group), the acute changes were significant, $F(1/37) = 226.36$, $p < 0.01$ for SBP, $F(1/37) = 57.06$, $p < 0.01$ for DBP, and the acute DBP change for the R group was greater than that of the F group, $F(1/37) = 6.12$, $p < 0.05$ (Figure 2C-2). The nonmedicated subgroup also showed a marginal group × time effect for acute DBP change over both treatment phases, $F(9/81) = 1.85$, $p < 0.10$, again indicating the tendency for R to have a greater effect on acute DBP lowering (Figure 2C-2).

The Lowering of SBP During Biofeedback Practice

The F technique was monitored by recording the difference between the SBP at the start of the F procedure and the lowest SBP that the patient was able to achieve in that practice session. Average reductions for the F group in the first treatment phase were significantly different from zero, $F(1/31) = 80.53$, $p < 0.01$ and improved from the first 35 days to the last 35 days, −4.9 mm Hg to −5.8 mm Hg, $F(1/31) = 5.13$, $p < 0.05$. During the second treatment phase, the effect of previous experience on performance of F was examined by comparing FF patients with RF patients. These groups did not differ, $F(1/31) = 0.02$, but did tend to achieve greater SBP lowering during the last 35 days of treatment (−4.8 mm Hg to −5.4 mm Hg, $F(1/31) = 3.87$, $p < 0.10$.

Long-term Effects of Behavioral Treatment

Figure 3 presents the differences in BP levels at each time of day from baseline to the end of each treatment phase. All groups lowered their average self-determined SBP and DBP between baseline and the end of the first treatment phase as well as between baseline and the end of the second treatment phase. These changes are different from zero ($p < 0.01$) for all groups between baseline and the first treatment phase, $F(1/85) = 98.60$ (SBP), $F(1/85) = 86.64$ (DBP); and between baseline and the second treatment phase, $F(1/74) = 88.44$ (SBP), $F(1/74) = 96.70$ (DBP). Furthermore, the greatest reduction for all groups (−6.0 mm Hg to −12.2 mm Hg for SBP; −3.7 mm Hg to −9.6 mm Hg for DBP) occurred during the afternoon (Figure 3). Changes in professionally determined BPs also were different from zero ($p < 0.01$) between baseline and the first treatment phase: −4.2 mm Hg (SBP), $F(1/82) = 19.18$, −3.2 mm Hg (DBP), $F(1/82) = 19.34$; and between baseline and the second treatment phase: −5.6 mm Hg (SBP), $F(1/77) = 28.67$, −4.4 mm Hg (DBP), $F(1/77) = 42.49$.

Figure 4 shows that, as reported earlier (1), both SBP and DBP were highest during the afternoon. Furthermore, the linear trend throughout the day was significant

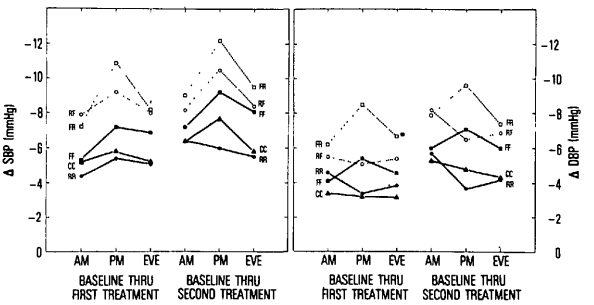

Fig. 3. Differences in average SBP or DBP between baseline and the last 35 days of each treatment phase for three times of day: AM = morning, PM = afternoon, EVE = evening.

and positive (evening higher than morning) for SBP, but significant and negative (evening lower than morning) for DBP; and average professionally determined pressures were comparable to, but slightly lower than, afternoon self-determined pressures. Figure 4 also shows an overall drop in BP from baseline to the end of the treatment period for all groups and a separation of BP levels of the behaviorally treated groups from those of the control group.

Differences Among Behavioral Treatment Groups (Self-Determined BPs) BP Level

Figure 5 shows average afternoon BPs for each of the five patient groups, covering five different time periods from baseline through the second treatment phase. Graphs of morning and evening BPs are similar; however, the greatest differences appear during the afternoon. Comparative results from all times of day, and for different pharmacological groups, are summarized in Table 2.

No differences were found in self-determined SBP levels at any time of day between behaviorally treated patients and controls for the combined group or for the medicated or nonmedicated subgroups (Table 2). However, there were significant differences in self-determined DBP levels between behaviorally treated and control patients in the combined group both in the afternoon, $F(1/85) = 8.67$, $p < 0.01$, and evening, $F(1/85) = 8.74$, $p < 0.01$. These differences were present in both the medically treated and the nonmedicated subgroups, but they were consistently reliable in the nonmedicated patients only: afternoon, $F(1/41) = 7.77$, $p < 0.01$; evening, $F(1/41) = 5.52$, $p < 0.05$.

When self-determined BP levels of specific behavioral treatment groups were compared with that of the control group using Brant and Duncan's modification (14) of Waller and Duncan's k-ratio t-test (13), no significant differences in SBP levels were found. However, each of the four behavioral treatment groups in the combined population had lower afternoon and evening self-determined DBP levels

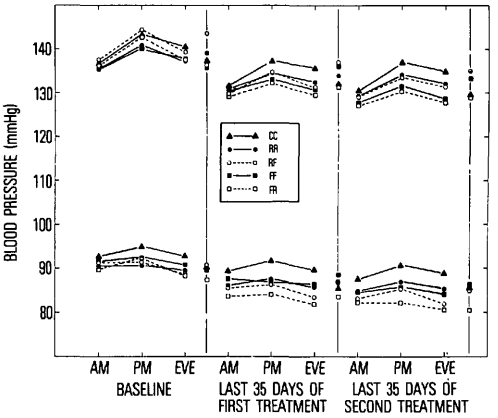

Fig. 4. Intradaily variations in SBP or DBP during baseline and the last 35 days of each treatment phase. Average professionally determined BP levels are indicated for the five treatment groups on the vertical line to the right of the corresponding self-determined levels. AM = morning, PM = afternoon, EVE = evening.

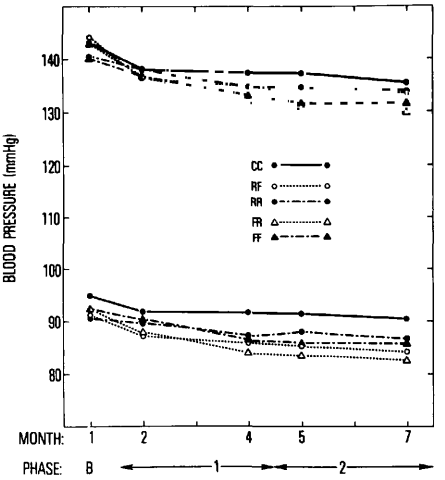

Fig. 5. Average afternoon self-determined BP levels for medicated and nonmedicated patients combined during each of the five measurement periods. B = baseline, 1 = first treatment phase, 2 = second treatment phase.

TABLE 2. Summary of Analysis of Variance and Post-hoc Tests[a] of Long-term Treatment Results

	All Treatments (T) vs Control (C)		Any Treatment (T) vs Control (C)	
	Level	Trend	Level	Trend
Combined	T < C	T > C	< C, $p \leq .05$	> C, $p \leq .05$
SBP morning				
DBP morning	*	*	FR	
SBP afternoon		*		FR
DBP afternoon	***	*	RR,RF,FR,FF	FR
SBP evening				
DBP evening	***	*	RR,RF,FR,FF	FR
Nonmedicated				
SBP morning				
DBP morning	*		RF,FR,FF	RF,FR
SBP afternoon				FR
DBP afternoon	***		RR,RF,FR,FF	FR
SBP evening				
DBP evening	**		RR,RF,FR	
Medicated				
SBP morning				
DBP morning				
SBP afternoon				
DBP afternoon				
SBP evening		*		FR,FF
DBP evening	*		RF,FR	

[a]Waller and Duncan (13) or Brant and Duncan (14).

*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

than did controls;[2] $F(1/85) = 8.67$, $F(3/85) = 0.63$ (afternoon); $F(1/85) = 8.74$, $F(3/85) = 1.67$ (evening); and the FR group had lower morning DBP levels, $F(1/85) = 3.14$, $F(3/85) = 0.71$. For the nonmedicated subgroup, all behavioral groups had lower DBPs than did controls in the afternoon: $F(1/41) = 7.77$, $F(3/41) = 0.32$; all except RR were lower than CC in the morning: $F(1/41) = 2.92$, $F(3/41) = 0.53$; and all except FF were lower in the evening, $F(1/41) = 5.52$, $F(3/41) = 1.10$. For the medicated subgroup, only RF and FR evening self-determined levels were lower than that of CC, $F(1/39) = 3.41$, $F(3.39) = 0.52$ (Table 2).

BP Trend

All groups, including controls, experienced significant reductions in BP

[2]Whenever comparisons are reported that use Brant and Duncan's modification of Waller and Duncan's *k*-ratio *t*-test, the first *F*-ratio will be that for treatment vs controls and the second will be that for treatments comparisons. All such tests were done using the 5% level of significance.

through the course of this study (Figure 5). Regressions (BP trend) for the curves such as those of Figure 5 were different among the four behavioral treatment groups only for the DBP of the combined group in the afternoon, $F(3/85) = 2.78$, $p < 0.05$. Furthermore, BP trend did not differ significantly for the comparison of behaviorally treated patients with controls for either SBP or DBP at any time of day or for either pharmacological grouping. However, for the DBP of the combined group, a consistent pattern is evident in that the data for all times of day show that the average regression of DBP among behaviorally treated patients tends ($p < 0.10$) to be more negative than that of controls, $F(1/85) = 3.31$ (morning), $F(1/85) = 3.81$ (afternoon), $F(1/85) = 2.97$ (evening). This tendency also was observed for the afternoon SBP trends in the combined group, $F(1/85) = 2.79$, $p < 0.10$.

When the BP trends of specific behavioral treatment groups were compared with control group trend using Brant and Duncan's (14) modification of the Waller and Duncan test (13), the combined FR group had a more negative trend ($p < 0.05$) for both SBP and DBP during the afternoon: $F(1/85) = 2.79$, $F(3/85) = 2.12$ for SBP, $F(1/85) = 3.81$, $F(3/85) = 2.78$ for DBP; and for DBP only in the evening, $F(1/85) = 2.97$, $F(3/85) = 1.17$. For the nonmedicated subgroup, the FR group had greater negative SBP trend than did controls during the afternoon: $F(1/41) = 0.42$, $F(3/41) = 2.62$, and greater negative DBP trend during both the morning, $F(4/41) = 1.80$, $F(3/41) = 1.49$, and the afternoon, $F(1/41) = 2.58$, $F(3/41) = 1.85$. DBP trend also was more negative than control for the RF group in the morning. For the medicated subgroup, the only trends more negative than control occurred for SBP of the FR and FF groups during the evening, $F(1/39) = 3.14$, $F(3/39) = 0.53$ (Table 2).

Application of F and R

The appearance of the curves in Figure 5 suggests that those patients receiving both F and R (RF and FR) performed consistently better at lowering BP than did those receiving a single treatment (FF and RR), but the differences in BP level or trend were not significant by the method of Brant. The differences between those receiving R first (RF) and those receiving F first (FR) also were not significant for either level or trend, nor were the differences between those receiving only F (FF) and those receiving only R (RR). Nonetheless, there is a consistent tendency for the FR and RF groups to perform better than CC (Table 2) and for the FF and FR groups (F-first treatment mode) to do better than the RR and RF groups (R-first treatment mode).

Professionally Determined BPs

Figure 6 shows average professionally determined BPs for each behavioral treatment group in the combined population. The first point on each curve represents the BP used for selection of subjects into the study, that is, those obtained from medical records. Comparable graphs for the medicated and nonmedicated subgroups are similar in appearance. The behaviorally treated patients did not differ as a group from controls in either BP level or BP trend. However, the CC group tended ($p < 0.10$) to have *lower* SBP levels in the combined population, $F(1/85) = 2.74$, and the medicated subgroup, $F(1/39)$

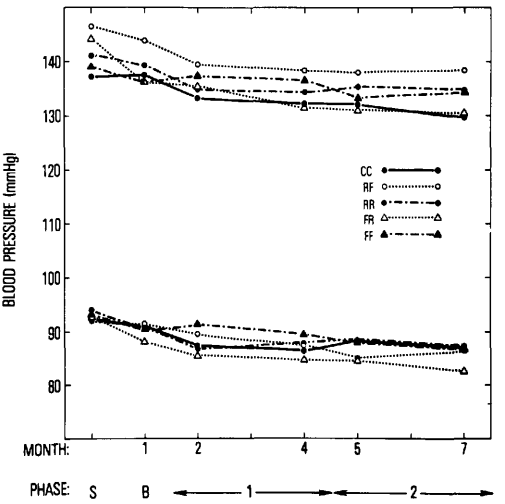

Fig. 6. Average professionally determined BP levels for medicated and nonmedicated patients combined during each of six measurement periods. S = selection phase, B = baseline, 1 = first treatment phase, 2 = second treatment phase.

= 3.34. The negative trend in SBP was greater ($p < 0.05$) than control for the FR group in the combined population, $F(1/85) = 2.74$, $F(3/85) = 1.22$, and in the nonmedicated subgroup, $F(1/41) = 1.69$, $F(3/41) = 3.0$; and it tended ($p < 0.10$) to be greater for the nonmedicated RF group. The changes in average professionally determined BP (mm Hg SBP/mm Hg DBP) from the selection phase to the final treatment phase were as follows: −7.3/−6.0 (CC), −6.2/−7.0 (RR), −4.7/−6.2 (FF), −8.0/−5.6 (RF), and −13.8/−10.2 (FR). Changes were significantly different from control ($p < 0.05$) for the FR group only; $F(1/36) = 5.54$ (SBP), $F(1/36) = 4.78$ (DBP).

Effect of the First Behavioral Treatments on BP Variables

Blood pressure levels and lability (standard deviation and intradaily range) were compared by repeated measures analysis of variance on data from the baseline period and the first 35 days and last 35 days of the first treatment phase. Professionally measured pressures also were analyzed in this way, with patients divided into medicated, nonmedicated, and combined groupings.

While the medicated subgroup exhibited no change in any of these variables as a result of activities in the first treatment phase, the nonmedicated patients who

received training in either R or F achieved DBP levels in the afternoons and evenings that were lower than those of the C group: $F(1,43) = 7.12$, $p < 0.05$ (afternoons), $F(1,43) = 4.61$, $p < 0.05$ (evenings).[3] The nonmedicated, behaviorally treated patients also showed a greater reduction in standard deviation of SBP in the morning, $F(1,43) = 5.66$, $p < 0.05$, and evening, $F(1,43) = 5.90$, $p < 0.05$, during the first treatment phase than did the C group; and the declining trend in their afternoon DBP levels was greater than that of the C group, $F(1, 43) = 4.64$, $p < 0.05$.

The differences between behaviorally treated patients and controls in afternoon and evening DBP levels were sufficient among the nonmedicated patients to yield differences when nonmedicated and medicated groups were analyzed as a combined group, $F(1,87) = 6.97$, $p < 0.01$ (afternoon), $F(1,87) = 7.00$, $p < 0.01$ (evening). There was also a tendency ($p < 0.10$) for DBP trends to be more negative in behaviorally treated patients than in controls at all times of day: morning $F(1/87) = 2.69$, afternoon $F(1/87) = 3.37$, and evening $F(1/87) = 2.46$. Furthermore, in the combined group, the declining trend in afternoon DBP was greater in the patients practicing F than in those practicing R, $F(1,87) = 4.38$, $p < 0.05$.

Thus the effects of behavioral therapy were evident during the first treatment phase and the effects of F on DBP were already distinguishable as compared to blood pressure monitoring alone or monitoring in combination with R.

[3]The lower evening DBP levels exhibited by nonmedicated, behaviorally treated patients in comparison with nonmedicated controls were not significant when analyses of variance were run on differences from baseline evening DBP levels.

DISCUSSION

These results show that patients with borderline elevations in BP will improve in a program of regular self- and professional BP monitoring coupled with considerable patient involvement in the assessment of their progress. The findings also show that significant additional lowering of BP can be achieved by adding R or F to the program, and they suggest that behavioral treatment of BP can be optimized by combining monitoring, F, and R in a stepped-care treatment regimen. Furthermore, the evidence suggests that this form of treatment is most effective for patients who are not taking antihypertensive medication. It should be emphasized that the results reported here have been compared with those of an extended baseline period, during which both SBP and DBP decreased significantly below the levels recorded in the patients' medical records (1). Therefore, the findings are conservative estimates of the impact that these behavioral interventions had on BP relative to those usually reported in clinical studies that typically use much shorter baseline periods.

Among the five treatment modes examined here, FR consistently produced the largest reductions in SBP and DBP over the course of the investigation. That a combination of R and F (FR or RF) was more effective than either single treatment (FF or RR) is consistent with the hypothesis that the two operate on different factors in the BP equation, namely that R achieves lower BP primarily through a reduction in cardiac output whereas F acts primarily by lowering peripheral vascular resistance. The fact that both SBP and DBP are lowered during R suggests that the lowered state of arousal associated with this practice re-

duces demand on the cardiovascular system leading to a reduction in cardiac output. The inhibition of K sounds during F is consistent with a lessening of tension in vascular smooth muscle sufficient to lower SBP. It is possible that with regular reduction of peripheral resistance using F, the myogenic response (15)—associated with sustained increases in peripheral resistance in response to elevated BP—could be lessened. One could speculate that the reduction of myogenic wall thickening in peripheral vessels led to a reversal of the vascular response to sustained HBP, resulting in the long-term reductions of both SBP and DBP observed here.

This line of reasoning also suggests a possible explanation for the faster rate of decline in BP achieved with FR as compared to RF. Although F patients switching to R for the second treatment phase were not given specific direction for continuing to use F, the latter stages of their F treatment had been devoted to generalization of the effects of F in an attempt to sustain BP reduction over longer periods of time. This was done through short practice sessions, practiced at opportune moments throughout the day, and patients were advised to continue these mini-F sessions ad libitum while practicing R according to the treatment protocol. Thus the FR patients had 6 months during which F could have been acting to reduce peripheral vascular tension as compared to 3 months of this for the RF group. The therapeutic advantage gained by the RF and FR groups, then, may have been due to the combined reduction of both cardiac output and peripheral resistance; and the added advantage gained by the FR group could have been due to the longer period of time that they had for reversal of myogenic thickening in peripheral blood vessel walls.

It also is interesting that, while patients taking diuretic antihypertensives achieved significant reductions in BP during the study period, the data for this subgroup do not suggest that behavioral therapy led to significant improvement over the reduction obtained by the control patients (Table 2). Thus it is possible that reduction in peripheral resistance attributable to long-term thiazide therapy in our medicated subgroup was sufficient to prevent further reduction of vascular tone by R or F and that the reduction in BP experienced by these patients was associated, in some nonspecific way, with the added attention to BP brought about by the requirement for extensive monitoring and assessment. However, it should be recalled that the prebaseline data reported earlier (1) show that the medicated patients entered this study with lower average DBP than did nonmedicated patients. Furthermore, they were older. Therefore, although the explanation just suggested for the difference in responsiveness of medicated and nonmedicated subjects to behavioral therapy is consistent with the data, other factors also distinguish the two groups.

Since the responsiveness of these borderline hypertensive patients to BP monitoring was so favorable, the use of self-monitoring in conjunction with regular professional monitoring and significant patient involvement in data assessment is clearly justified as an initial stage in the management of borderline HBP. Thus we suggest that this should be the first step in a stepped-care program for control of borderline HBP. If this proves to restore normal BP, further treatment would be unnecessary. However, if BP remained stable but elevated after about 1 month of monitoring, behavioral intervention should begin with F; to be followed,

in about 3 months, by R if necessary. It is possible that the combination of these procedures with other behavioral interventions such as dietary salt restriction, weight reduction, and regular exercise could significantly reduce the need for antihypertensive pharmacotherapy.

We are grateful to the staff of the Columbia Medical Plan for their assistance with this study. In particular, we wish to thank Charles Taylor, M.D., Chief of Internal Medicine, for his support throughout. We are also grateful to Dr. Larry J. Brant for his contribution to the statistical analyses used in this work, and to Mr. Richard H. Mathias for his dedicated assistance with many technical aspects of the study.

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