*BIOFEEDBACK, AUTOGENIC TRAINING, AND
PROGRESSIVE RELAXATION IN THE TREATMENT OF
RAYNAUD'S DISEASE: A COMPARATIVE STUDY*

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Twenty-one female patients suffering from diagnosed idiopathic Raynaud's Disease were trained to raise digital skin temperature using either autogenic training, progressive muscle relaxation, or a combination of autogenic training and skin temperature feedback. Patients were instructed in the treatment procedures in three one-hour group sessions spaced one week apart. All patients were instructed to practice what they had learned twice a day at home. Patients kept records of the frequency of vasospastic attacks occurring over a four-week baseline period, and during the first four weeks and the ninth week of training. In addition, patients underwent four laboratory cold stress tests during which they were instructed to maintain digital temperature as the ambient temperature was slowly dropped from 26° to 17°C. Cold stress tests were given during week 1 of baseline and during weeks 1, 3, and 5 of training. Results indicated that all patients improved during the first four weeks of training. No significant differences between the three behavioral treatment procedures were obtained. In addition, the ability of patients to maintain digital temperature during the cold stress challenge showed significant improvement from the first to the last tests. Symptomatic improvement was maintained by all patients nine weeks after the start of the training. The implications of these findings for the behavioral treatment of Raynaud's Disease are discussed.

DESCRIPTORS: Raynaud's Disease, progressive relaxation training, autogenic training, behavioral medicine, female patients

Raynaud's Disease is a painful vasospastic disorder usually affecting the digits in the hands and feet. The etiology of the disorder in its idiopathic form is unclear and the efficacy of current surgical and pharmacologic treatments is questionable (Spittel, 1972). During a vasospastic episode the affected area goes through a three-stage color change; first blanching, then turning cyanotic blue, and finally becoming bright red as the vasospasm is relieved and reactive hyperemia ensues. Although the pathophysiology of the disease is not understood, it is widely accepted that activity of the sympathetic nervous system is a major contributing factor (Spittel, 1972).

During the last decade, biofeedback and other behavioral techniques have been used in controlled laboratory studies to teach voluntary control of digital skin temperature in normals (Keefe, 1975, 1978; Keefe & Gardner, 1979; Surwit, Shapiro, & Feld, 1976; Taub & Emurian, 1976). These techniques have become utilized in the management of patients suffering from Raynaud's Disease (Surwit, 1973; Taub, 1977). Unfortunately, most of the literature on the behavioral treatment of Raynaud's Disease consists of uncontrolled case studies. However, in a recent controlled study, Surwit, Pilon, and Fenton (1978) compared a combination of skin temperature feedback and autogenic training with autogenic training alone in the treatment of idiopathic Raynaud's Disease. Thirty female patients were trained to control their digital skin temperature using either autogenic training or a combination of autogenic training and skin temperature feedback. Patients were trained

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in either a laboratory setting or at home. All trained patients demonstrated the ability to maintain digital skin temperature in the presence of a cold stress challenge as compared to untreated controls. Also, trained patients reported significant reductions of both the frequency and intensity of vasospastic attacks. The addition of skin temperature feedback to autogenic training did not provide any further clinical benefit. Although this study provided a demonstration of the efficacy of a behavioral strategy in the treatment of Raynaud's Disease under controlled conditions, it left several questions unanswered. Patients receiving biofeedback were given six laboratory training sessions supplemented by home practice with small liquid crystal adhesive strips. Because these are relatively insensitive temperature monitoring devices it could be argued that patients lacked sufficient exposure to accurate skin temperature feedback and therefore the utility of skin temperature feedback was not adequately tested in this design. Secondly, the study left to question the mechanism of improvement in treated patients. Although skin temperature feedback was not seen to provide additional benefits, it was not clear whether autogenic training was providing patients with anything in addition to general relaxation. Finally, although before and after treatment effects were observed, progressive changes in voluntary vasomotor control were not tested under laboratory conditions.

The purpose of the present study was threefold: First, the study attempted to assess the comparative efficacy of a general relaxation procedure other than autogenic training in treating Raynaud's Disease. If autogenic training operates via a general reduction in sympathetic nervous system activity, then more than one relaxation procedure should be effective in producing vasodilation. Second, this study attempted to examine change in performance by using repeated cold stress challenges over the course of treatment. If patients showed gradual improvement over repeated cold stress tests, a stronger argument could be made that this was a result of

learning. Finally, the study attempted to assess more adequately the role of skin temperature feedback in training voluntary vasodilatation by employing sophisticated electronic feedback devices in home training. It was felt that these more sophisticated devices would provide subjects with temperature feedback that was much more accurate than that provided in home training in the earlier study.

METHOD

Subjects

Subjects were 21 female patients who met the criteria outlined by Allen, Barker, and Hines (1955) for the diagnosis of Raynaud's disease. These criteria include: (1) the attacks are precipitated by exposure to cold or emotional stimuli; (2) there is bilateral involvement; (3) gangrene is absent; and (4) there is no evidence of any primary disease or other vasomotor irregularities that may be responsible for the vasospasms. All patients received the diagnosis of primary Raynaud's disease from their referring physician and were also screened by one of the investigators to ensure that they met the above criteria.

Apparatus

Physiological measures were recorded on an 8-channel Beckman Type R dynograph. Digital temperature was measured with two Yellow Springs #729 thermolinear thermistors taped 1 to 1.5 cm distal to the distal interphalangeal joint of the middle finger on the left and right hands. Heart rate was measured with a Lexington Instrument cardiometer from electrodes attached in a standard lead I configuration. The laboratory consisted of two separate rooms, one containing the polygraph and programming equipment and the other housing the patient. The two rooms were interconnected by intercom and closed circuit television. The patient room was controlled for temperature and humidity by an air conditioning reheating sys-

tem that held the temperature constant within 1°C at any specified temperature.

Readings of the daily average outdoor temperature for the metropolitan Boston area were obtained from records maintained by the National Climatic Center in Asheville, N.C. Records of outdoor temperature were thus available for each day the study was in progress.

Evaluation Procedures

Two major sources of data were used to evaluate the efficacy of treatment: (1) patient self-reports, and (2) cold stress tests.

Self-report data were gathered by all patients for four weeks prior to training, for the first four weeks of training, and for the ninth week of training. Patients were instructed to record the frequency of vasospastic attacks. Data sheets were filled in daily and mailed to the laboratory on a weekly basis.

All patients received four cold stress tests in the laboratory. The first stress test was given one month prior to the treatment. The three remaining stress tests were given during weeks one, three, and five of training. During stress tests, patients were seated in a comfortable chair with their hands inserted through plexiglass boxes which were open at the end. This arrangement allowed for standardization of hand position and a shield against drafts. Patients were dressed in only their undergarments covered by a standard light terry cloth robe. After thermistors and heart rate electrodes were attached by the experimenter, the patient was left in the temperature controlled room alone for the duration of the stress test. During the first 10 min of the test, the temperature of the room was maintained at 26°C. Patients were then instructed to try to keep their hands as warm as possible. Over the next 8 min, the temperature of the room was slowly lowered to 20°C and maintained at that level for 11 min. During the final 7 min of the test, the temperature of the room was lowered to 17°C. Throughout the stress test, communication between the patient and the experimenter was maintained by an

open intercom and closed circuit television. The patient was asked not to speak to the experimenter unless she became uncomfortable. Patients were told that they could withdraw from the stress test at any time if they experienced undue discomfort. None of the patients asked that any stress test be discontinued, however.

Experimental Design

The experiment was based on mixed design with between group comparison of treatment (autogenic training, progressive relaxation, and autogenic biofeedback) with repeated measure factors for multiple stress tests and trial blocks within each stress test. A no treatment control group was not employed since it had previously been demonstrated that autogenic training was superior to a no treatment control (Surwit et al., 1978). Thus the experimental design focused on the questions of differential treatment effects and the response of treated patients to multiple stress tests.

Training Procedures

Patients were randomly assigned to one of the three treatment conditions: (1) autogenic training, (2) progressive relaxation, and (3) autogenic biofeedback training. Patients in each condition were trained in small groups which met for three one-hour sessions during the months of January and February 1978.

Autogenic Training

Patients in this condition received an adaptation of autogenic training, (Schultz & Luthe, 1969). During training session one, the rationale for autogenic training was discussed and patients were given brief cassette tape-recorded autogenic training instructions focusing on heaviness. Patients were instructed to practice with the cassette tape for two 20-minute training sessions per day. In addition, patients were encouraged to become more aware of variations in hand temperature that occur during the day. During the second training session, patients were given a second cassette tape with a slightly

different set of autogenic instructions emphasizing warmth. Patients were told to practice with this second tape twice daily for the duration of the study. During the third training session, patients were instructed in a response generalization technique described by Surwit *et al.* (1978). Briefly, in addition to practicing with their cassette tape twice daily, patients were told to practice warming their hands in a variety of daily situations for brief periods of time (30 to 60 sec). These practice periods were to be conducted without the use of the cassette tape. Patients were given a packet of stars to be placed around home, work, and recreational environments. The stars were used to cue patients to practice warming their hands. Patients were told to place enough stars in their environment to enable them to practice 20 to 30 times per day. The main purpose of this "habit training" was to facilitate transfer of learned temperature control from the home to other environments.

Progressive Relaxation Training

Patients in this condition received a modified version of Jacobson's (1964) progressive relaxation training similar to that widely employed by behavior therapists in the treatment of anxiety and tension related disorders (Keefe & Surwit, 1978; Surwit & Keefe, 1978). The format for training was similar to that described for the autogenic training condition except that the cassette tape given to patients contained instructions for muscular relaxation training rather than autogenic training. During training session one, patients were given a rationale for the use of relaxation training and also given the training tape. During training session two, the training tape was reviewed a second time. During training session three, patients were instructed in the response generalization technique as were patients in group 1.

Autogenic Feedback Training

Patients in the autogenic biofeedback condition received all the instructions and materials given to patients in the autogenic training con-

dition. In addition, these patients were given portable Cyborg Model J42 temperature biofeedback units for use in training. These devices provide patients with instantaneous audio and visual feedback of skin temperature changes of up to .01°C and are commonly used in clinical biofeedback practice. Patients were instructed to use the units during daily home practice sessions with the cassette tape. The patients were told to attach the thermistor to the middle finger of their dominant hand for purposes of home feedback training. All patients had the portable biofeedback units for the first five weeks of training.

RESULTS

Cold Stress Tests

Each of the psychophysiological measures was scored in 75 sec-time segments. Skin temperatures were obtained from both the right and left hands at the end of each 75-sec segment. Heart rates were the number of beats per 75-sec segment. Measurements of heart rate and skin temperature were taken for trials 1, 5, 10, 15, 20, 25, and 30 of each of the laboratory cold stress tests. The data gathered were analyzed using two separate ANOVAs. The between groups factor for both analyses was type of training (autogenic versus progressive relaxation versus autogenic biofeedback). For the analysis of heart rate data, the within group factors included time (test 1 versus 2 versus 3 versus 4) and, trials (1, 5, 10, etc.). The ANOVA for the temperature data included an additional within group factor of hand (left versus right).

Skin temperature. In the analysis of skin temperature data the main effects of Time ($F = 4.46$, $df = 3,54$, $p < .01$) and Trials ($F = 104.52$, $df = 6,108$, $p < .001$) were significant. There were no significant differences between the temperature of right versus left hand, nor were there any significant differences in the performance of the three training groups. Figure 1 displays the average skin temperature for all patients during the four stress tests. Pa-

tients tended to start each cold stress test with a hand temperature that was warmer than that of the previous test. Patients were also generally able to maintain this higher skin temperature over the range of the drop in ambient temperature. Although patients' performance on the cold stress tests showed improvement over training, post hoc comparisons of session temperature grand means using Tukey's HSD revealed that statistically significant ($p < .05$) improvements over baseline (Stress test 1) performance occurred for only the final stress test.

Heart rate. The only statistically significant effect obtained in the analysis of heart rate data was that due to the Trials factor ($F = 12.00$, $df = 6,108$, $p < .001$). Patients significantly decreased heart rate during the cold stress test. Heart rate decreased from an average of 75.4 bpm in trial 1 to 70.9 bpm in trial 30.

Home Records

Figure 2 displays the mean number of vasospastic attacks per day occurring during the

Fig. 1. Mean digital temperature during pretreatment stress tests (Stress test 1) and posttreatment stress tests (Stress test 2-4). Recording of skin temperature began after a 10-min stabilization period.

four weeks of baseline, first four weeks of training, and during the ninth week of training.

Baseline period. A two factor repeated-on-one ANOVA was used to analyze differences in the number of attacks occurring during the four weeks of baseline. Although there were no significant differences in the number of attacks during the baseline period, the effect of groups approached significance ($F = 3.24$, $df = 2,18$, $p < .06$). Inspection of Figure 2 reveals that the random assignment of patients to conditions may not have served to adequately equate baseline levels between conditions; subjects in the autogenic biofeedback group had fewer attacks than subjects in the two other conditions.

Training period. Data on the frequency of vasospastic attacks occurring during four weeks of training and the ninth week of training were analyzed by means of an analysis of variance. Significant main effects were obtained for Groups ($F = 5.03$, $df = 2,18$, $p < .05$) and Weeks ($F = 15.38$, $df = 4,72$, $p < .001$). In addition,

the interaction of Groups $\times$ Weeks ($F = 2.49$, $df = 8,72$, $p < .05$) was significant. The significant main effects indicate that the frequency of attacks during the training period was significantly affected by both treatment condition and time since onset of treatment. Additional statistical comparisons were made to facilitate interpretation of the interaction effect.

In order to determine the statistical significance of changes in the frequency of attacks occurring over the course of training, a series of within group comparisons was made. Comparisons between all possible pairs of means for each group were computed using Tukey's HSD statistic. Results indicated that patients who received either autogenic training or progressive relaxation training showed a significant ($p < .05$) decrease in the frequency of vasospastic attacks from the first to the fourth week of training. This reduction in the frequency of attack reached greater statistical significance ($p < .01$) after nine weeks of train-

Fig. 2. Mean number of attacks per day reported by all patients during the four weeks immediately preceding training, the first four weeks of training and the ninth week of training.

ing. While patients in the autogenic biofeedback condition showed similar symptomatic improvement over the course of training, the reductions in the frequency of attacks that were obtained failed to reach statistical significance, probably because of a floor effect.

Daily Outdoor Temperature

Figure 3 displays the average daily outdoor temperature occurring during baseline and training periods. Inspection of this figure reveals that the daily temperature showed a slight increase during baseline and dropped during the training period. An ANOVA conducted on outdoor temperature data from the first four weeks training and baseline yielded a highly significant F -value ($F = 205.37$, $df = 1,18$, $p < .001$) indicating the mean daily temperature

during the first four weeks of training (-2.06°C) was significantly lower than that during the four-week baseline period ($-.36^{\circ}\text{C}$). Also indicated on Figure 3 are the weeks in which cold stress tests were conducted. As can be seen, there was also a tendency for lower outdoor temperature to occur over the weeks that stress tests were given. A one-way ANOVA comparing outdoor temperature during the four weeks in which stress tests were conducted yielded a highly significant week effect ($F = 35.89$, $df = 3,54$, $p < .001$).

DISCUSSION

The results of this study support two major conclusions. First, a general relaxation procedure is just as effective as autogenic training in

Fig. 3. Average daily outdoor temperature in Boston for the four weeks immediately preceding training and the first five weeks and the ninth week of training. Data were obtained from the National Climatic Center in Asheville, N.C.

the treatment of Raynaud's Disease. Second, patients exposed to either a general relaxation, autogenic training or autogenic training coupled with intensive home biofeedback training show significant improvement in their ability to cope with cold ambient stress under controlled laboratory conditions.

This study, however, did not provide a definitive comparison between autogenic training and autogenic training plus home biofeedback training on the self-report of vasospastic attacks. Because patients who received the biofeedback training had fewer attacks during baseline their failure to show statistically significant reductions in vasospastic attacks during training is difficult to interpret. However, it should be pointed out, despite this problem, there was no significant difference in the cold stress performance of these two groups. It is the contention of the authors that these laboratory data are inherently more objective, reliable, and valid indicators of improvement than subject's self-reports. They do not suffer from the numerous methodological difficulties associated with self-observation (Keefe, Kopel, & Gordon, 1978). Furthermore these results are in agreement with previous research demonstrating that the combination of biofeedback and autogenic training is no more effective than autogenic training used alone in enhancing voluntary vasomotor control (Surwit *et al.*, 1978; Keefe, 1978).

The results of this study confirm the early report of Surwit *et al.* (1978) in showing that individuals suffering from Raynaud's Disease can utilize simple behavioral self-control techniques to maintain skin temperature in the face of a cold challenge. As in previous research (Surwit *et al.*, 1976; Surwit *et al.*, 1978) voluntary vasomotor control was accompanied by a decrease in heart rate within sessions. This finding implies that the effect is a general rather than specific one probably resulting from a decrease in central sympathetic activity as opposed to the specific neural control of the peripheral vasculature.

One of the most interesting findings in the

present study was the progressive improvement in patients' ability to deal with the standard cold stress challenge administered three times over five weeks of training. On each occasion patients exhibited increased resistance to the cold stress. These findings were not considered to result from habituation because it had been previously demonstrated that untrained patients actually deteriorate in response to repeated cold stress challenge (Surwit *et al.*, 1978).

Patients in this study were trained during the coldest months of 1978. Analysis of outdoor temperature during both baseline and training periods revealed that patients continued to improve even as the outdoor temperature dropped. Although one might interpret this as a side effect of patients wearing warmer clothes as the temperature declined, the frequency and intensity of vasospasms in Raynaud's Disease usually increases as outdoor temperature declines (Spittell, 1972).

These data, in combination with the earlier work of Surwit *et al.* (1978), clearly demonstrate that behavioral techniques can be of significant benefit to the symptomatic management of primary idiopathic Raynaud's Disease. Neither biofeedback nor specific suggestion techniques appear to be necessary to achieve this effect. Recent research conducted in this laboratory has indicated that these techniques can be used to help patients manage vasospastic symptoms of scleroderma and other collagen vascular diseases (e.g., Keefe, Surwit, & Pilon, Note 1). Although future work needs to be done to assess the physiological mechanisms by which such improvements are achieved, it is now clear that relatively simple and economical relaxation techniques already widely employed by behavior therapists can be useful in the management of certain vasospastic diseases.

REFERENCE NOTE

1. Keefe, F. J., Surwit, R. S., & Pilon, R. N. Collagen vascular disease: Can behavior therapy help? Paper presented at the meeting of the Association for the Advancement of Behavior Therapy, Chicago, 1978.

REFERENCES

- Allen, E. V., Barker, N. W., & Hines, E. A. *Peripheral vascular disease*. Philadelphia: W. B. Saunders, 1955.
- Jacobson, E. *Anxiety and tension control: A physiologic approach*. Philadelphia: J. B. Lippincott, 1964.
- Keefe, F. J. Conditioning changes in differential skin temperature. *Perceptual and Motor Skills*, 1975, **40**, 283-288.
- Keefe, F. J. Biofeedback vs. instructional control of skin temperature. *Journal of Behavioral Medicine*, 1978, **1**, 383-390.
- Keefe, F. J., & Gardner, E. T. Learned control of skin temperature: Effects of short and long-term biofeedback training. *Behavior Therapy*, 1979, **10**, 202-210.
- Keefe, F. J., Kopel, S., & Gordon, S. B. *A practical guide to behavioral assessment*. New York: Springer, 1978.
- Keefe, F. J., & Surwit, R. S. Electromyographic Biofeedback: Behavioral treatment of neuromuscular disorders. *Journal of Behavioral Medicine*, 1978, **1**, 13-24.
- Schultz, J. H., & Luthe, W. *Autogenic methods*. New York: Grune & Stratton, 1969.
- Spittell, J. A., Jr. Raynaud's phenomenon and allied vasospastic conditions. In J. F. Fairburn, J. L. Juergens, & J. A. Spittell, Jr. (Eds.), *Allen, Barker and Hines: Peripheral vascular diseases*. Philadelphia: W. B. Saunders, 1972.
- Surwit, R. S. Biofeedback: A possible treatment for Raynaud's Disease. *Seminars Psychiatry*, 1973, **5**, 483-489.
- Surwit, R. S., & Feefe, F. J. Frontalis EMG biofeedback: An electronic panacea? *Behavior Therapy*, 1978, **9**, 779-792.
- Surwit, R. S., Pilon, R., & Fenton, C. H. Behavioral treatment of Raynaud's Disease. *Journal of Behavioral Medicine*, 1978, **1**, 323-335.
- Surwit, R. S., Shapiro, D., & Feld, J. L. Digital temperature autoregulation and associated cardiovascular changes. *Psychophysiology*, 1976, **13**, 242-248.
- Taub, E. Self-regulation of human tissue temperature. In G. E. Schwartz, & J. Beatty (Eds.), *Biofeedback: Theory and practice*. New York: Academic Press, 1977.
- Taub, E., & Emurian, C. S. Feedback aided self-regulation of skin temperature with a single feedback locus, 1. Acquisition and reversal training. *Biofeedback and Self Regulations*, 1976, **1**, 147-168.

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