

Comparison of Behavioral Treatments for Raynaud's Disease

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Induced vasodilation by classical conditioning was compared to biofeedback therapy as treatment for idiopathic Raynaud's disease. Classical conditioning therapy consisted of 54 10-min immersions of both hands in water (43°C) simultaneously with whole-body exposure to cold air (0°C), given three times per day, 3 days per week, for 6 weeks. Biofeedback therapy consisted of eight sessions of electromyograph feedback (frontalis) while listening to relaxation tapes, followed by 10 sessions of digital thermal feedback while listening to relaxation tapes. Both groups received 10-min cold stress tests of whole-body exposure to 0°C before and after treatments. Results indicated that both therapies significantly increased the digital temperature response to cold. Although no differences between classical conditioning and biofeedback were found at the end of training, a 1-year follow-up indicated that classical conditioning was more effective.

KEY WORDS: biofeedback; classical conditioning; EMG; Raynaud's disease; thermal.

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The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation.

Human subjects participated in this study after giving their free and informed voluntary consent. Investigators adhered to Army Regulation 70-25 and United States Army Medical Research and Development Command Regulation 70-25 on Use of Volunteers in Research. The study protocol was approved by the USARIEM and USAMRDC human use review committees.

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INTRODUCTION

Raynaud's disease is characterized by extreme vasospastic attacks of the hands and/or the feet. Attacks are precipitated by cold or emotional distress and are more likely to affect women than men. Typically, episodes are accompanied by a serial tricolor skin change (white pallor-cyanotic blue-deep red). Raynaud's attacks may be idiopathic or secondary to occlusive vascular disease or connective-tissue disease, the latter being referred to as Raynaud's phenomenon (Blain *et al.*, 1951; Winsor, 1959). Medical treatment of Raynaud's disease involves avoidance of cold and emotional upset, vasodilating drugs, plasmapheresis (Talpos *et al.*, 1978), calcium channel blocking agents (Kahan *et al.*, 1981), thyroid hormone (Shagan and Friedman, 1980), reserpine, and sympathectomy (Winsor, 1959). Behavioral treatments have also been widely used in the management of Raynaud's disease (cf. Surwit *et al.*, 1982).

The most widely known method of behaviorally increasing blood flow to the hands is biofeedback, involving operant conditioning (e.g., Roberts *et al.*, 1973). Vasodilation via biofeedback has also been successfully demonstrated in a cooling environment (Newman, 1975; Taub, 1977). Attempts to apply these procedures to patients with Raynaud's disease have been moderately successful, with some studies combining biofeedback with other treatment modes (Surwit, 1973; Taub, 1977; Taub and Stroebel, 1978).

Hypnosis and relaxation have also received attention as treatments for vasoconstrictive syndromes (Jacobson *et al.*, 1973). Surwit *et al.* (1978) compared feedback plus autogenic training to autogenic training alone. They found increases in skin temperature and decreases in vasospastic attacks, with no improvement with the addition of feedback. A 1-year follow-up of 19 of these subjects indicated that performance on the cold stress test had deteriorated to pretreatment levels, although subjects did report fewer vasospastic attacks (Keefe *et al.*, 1979). Keefe *et al.* (1980) found that progressive muscle relaxation, autogenic training, and autogenic training plus feedback increased digital temperatures and decreased vasospastic attacks equally well. Freedman *et al.* (1983) compared digital thermal biofeedback, digital thermal biofeedback under cold stress, frontalis electromyograph feedback, and autogenic training. Feedback under cold stress was most effective in terms of both higher finger temperature and reduction in frequency of attacks. Grabert *et al.* (1980) found that feedback plus suggestion produced increases in digital skin temperatures, although neither method by itself was effective.

Marshall and Gregory (1974), using classical conditioning, found large increases in skin temperature and nerve-conduction velocity. Eight cold-hypersensitive subjects, three of whom exhibited idiopathic Raynaud's disease, were given six simultaneous pairings of a whole-body cold exposure of 0°C (conditioned stimulus) and immersion of the hands in hot (42°C) water (un-

conditioned stimulus). Jobe *et al.* (1982) found that subjects with Raynaud's disease who were treated with classical conditioning therapy (27 treatments) showed a significant improvement compared to untreated Raynaud's subjects. Overall, 13 of 17 idiopathic Raynaud's subjects showed large increases in skin temperatures on a cold stress test. Melin and Fagerstrom (1981) also found that classically conditioned Raynaud's subjects showed a significant improvement in both finger temperature and number of attacks compared to placebo-treated controls.

Except for the study by Jobe *et al.* (1982), most investigations have used small numbers of subjects or have not employed control groups. Many of these studies used subjective measures as indications of improvement. For those few studies which measured skin temperature during cold stress, only mild cold challenges (16–17°C) were employed.

The purpose of the present study was to compare classical conditioning therapy with biofeedback plus relaxation as treatment for idiopathic Raynaud's disease. It was also designed to evaluate the ability of biofeedback-trained patients to maintain skin temperature under more severe cold conditions (0°C) than have been previously studied.

METHOD

Subjects. Three male and 12 female volunteers from the local population were studied and were modestly reimbursed for their participation. The subjects ranged in age from 14 to 61 years and had had vasospastic attacks for an average of 11.0 years. Two of the subjects were smokers and eight had a family history of Raynaud's. Eight subjects had involvement of all digits excluding the thumbs; three had involvement of all digits including the thumbs; one had involvement of the middle, ring, and index fingers; and two had involvement primarily of the middle and ring fingers of each hand. Seven also had involvement of the feet. Only three subjects stated that emotional stress could induce vasospastic episodes. All subjects stated that cold weather induced attacks; nine said picking up or touching cold objects induced attacks; eight said chilling of only the hands induced attacks; seven said a sudden change in temperature induced attacks; three said chilling of the body, but not the hands, induced attacks; three said swimming induced attacks; and one said a shower or a bath induced attacks. All subjects were diagnosed as having idiopathic Raynaud's disease according to the criteria of Allen and Brown (1932). One subject did not complete the study and his data are not included in the analysis.

Each volunteer was interviewed, was given a physical examination, and had a medical history taken. During the interview the subjects completed

the Institute for Personality and Ability Testing (IPAT) Anxiety Scale Questionnaire (Cattell, 1957), the Eysenck Personality Questionnaire (Eysenck and Eysenck, 1975), a background questionnaire, and an environmental history questionnaire. To rule out possible complicating disease, all subjects had tests for rheumatoid factor, cold agglutinins, cryoglobulins, sedimentation rate, antinuclear antibody, and serum glucose levels. All tests results were within normal limits.

Instrumentation. The treatment response of the fingers to cold air before and after treatment was used as the dependent variable. Research has shown that a high correlation exists between blood flow and skin temperature at low temperatures (Hsieh *et al.*, 1965). Finger temperature was measured by thermocouples attached to the dorsal aspect of each finger (excluding thumb) proximal to the nail bed. Each subject was also fitted with a thermocouple rectal probe and an eight-point thermocouple harness to determine a mean-weighted skin temperature. The eight points monitored were the chest, lower back, abdomen, lateral upper arm, forehead, dorsal contralateral forearm, anterior thigh, and lateral calf. Temperatures were monitored continuously by a Digimax Scanning Numatron (Leeds and Northrup, North Wales, Pa.) and were collected by an on-line computer with temperature recordings reported every 60 sec.

Warm water for hand immersions was provided by two in-house fabricated stainless-steel water baths, each equipped with a plexiglass lid with two openings for the subject's hands, and controlled by a Thermomix 1460 (B. Braun, Melsungen, West Germany) proportional controller and stirrer. Two in-house fabricated hot air baths were also used, each equipped with a Proportional Control, Model 72 (Yellow Springs Instrument Co., Yellow Springs, Ohio).

Thermal feedback was provided by an Autogen 1000b feedback thermometer, and electromyograph feedback was provided using an Autogen 1100. Relaxation was induced using the Quietening Response Training audiocassette tapes (BMA Audiocassette Programs, New York).

Procedure. The study was conducted from January 1982 through March 1982, with treatments for both groups given on Mondays, Wednesdays, and Fridays for 6 consecutive weeks. The week before treatments began all subjects were tested to determine their digital temperature response to cold. On these days the subjects were seated in a room at $22 \pm 1^\circ\text{C}$ for 30 min to stabilize body temperatures. No external heating was applied to the subjects. They were exposed to a single, 10-min period of cold ($0 \pm 1^\circ\text{C}$) dressed in indoor clothing (light coveralls and boots), seated on a stool with arms at heart level. Digital temperature was recorded during the last minute of exposure. The cold test was repeated the week after the conclusion of treatments. The main comparisons for evaluating the treatment effects were these pre- and posttreatment tests.

The classical-conditioning paradigm was modeled after a counterconditioning procedure (e.g., Wolpe, 1958); previous experience had indicated that once vasoconstriction had occurred in patients with Raynaud's disease, vasodilation was extremely difficult to elicit. For the classical-conditioning group each subject changed into coveralls and boots, and was then equipped with thermocouples. Before entering the cold chamber, the subject sat for 5 min in a warm room ($22 \pm 1^\circ\text{C}$) and placed both hands in a box containing warm circulating air ($49 \pm 1^\circ\text{C}$) to prevent vasoconstriction. The subject then entered the cold chamber ($0 \pm 1^\circ\text{C}$) (conditioned stimulus) and immediately placed both hands in a hot water bath ($43 \pm 1^\circ\text{C}$) (unconditioned stimulus) for 10 min. After each treatment the subject was taken from the cold chamber for 5 min and again placed both hands in the warm air box for 5 min. This procedure was repeated twice for a total of three trials on each experimental day. Finally, the temperatures of the subject at room temperature ($22 \pm 1^\circ\text{C}$) were monitored for 5 min.

For the biofeedback plus relaxation group the subject waited in a warm room ($22 \pm 1^\circ\text{C}$) for 30 min in order to acclimate to room temperature on each treatment day. The subject, dressed in street clothes, then entered a sound proof room ($24 \pm 1^\circ\text{C}$), sat in a well-padded chair, and listened to relaxation tapes while receiving electromyograph feedback from the frontalis area of the head (8 sessions) and thermal feedback from the middle finger of the dominant hand (10 sessions), each session lasting 45 min–1 hr. At the conclusion of the training series, each subject was given a copy of the last audiocassette and was requested to practice the exercises at home.

On the last day of the experiment and approximately 1 year later, all subjects completed a questionnaire or interview rating the severity of their vasospastic attacks, the amount of pain experienced during an attack, and an estimate of the time it took their hands to recover from the attacks. These characteristics were rated on a five-point scale, with 5 being most improved, 3 being about the same, and 1 being worse than before treatments. All subjects returned the questionnaires.

Statistical Analysis. All data analyses were done using the mean digital temperature of the dominant hand at the end of the exposure to cold as the dependent measure. Data were analyzed using a one-way analysis of covariance (ANCOVA) with the subject's digital temperature on the before-treatment cold exposure as the covariate and the temperature on the after-treatment cold exposure as the dependent variable. Other comparisons were done using Student's *t* test.

RESULTS

There were significant increases in mean digital temperature from the pretest to the posttest for both treatment groups. Those treated with classical-

conditioning therapy showed a mean increase of 3.9°C [$t(5) = 4.44, P < 0.01$], whereas the group treated with biofeedback and relaxation training showed a mean increase of 4.1°C [$t(7) = 5.71, P < 0.002$]. Individually, five of six subjects in the classical-conditioning group showed increases of greater than 2°C (the other subject was later found to be pregnant), and six of eight subjects in the biofeedback-relaxation group showed an increase of greater than 2°C. None of the classically conditioned subjects and two of the feedback subjects (B5, B6) had attacks of Raynaud's during the posttest. There were no differences between the classical-conditioning group and the biofeedback-relaxation group in digital temperatures on the posttest ($F < 1$).

Results of subjective reports suggest that individuals in the classical-conditioning group (mean = 4.0) had less pain during their attacks than the feedback group (mean = 3.5) [$t(12) = 2.27, P < 0.05$], but there were no differences between the two groups in terms of severity of and recovery from the attacks. Results from the questionnaire sent out after 1 year suggest that the classical-conditioning group (mean = 4.83) had less severe attacks than the feedback group (mean = 3.63) [$t(12) = 2.99, P < 0.05$] but that the groups did not differ in terms of painfulness of the attacks or time to recover. Biofeedback-relaxation subjects were, in addition, asked whether they continued to practice the "quieting response" using the tape they were given. Five of eight indicated that they still listened to the tapes.

Contrary to the early literature, there was no evidence that subjects with Raynaud's disease who participated in this study were less emotionally stable than the normal population. Anxiety scores as measured by the Anxiety Scale Questionnaire (mean score = 24.1) did not differ substantially from the normal values of the test (27.1). Similarly, the subjects' scores on the "neuroticism" scale of the Eysenck Personality Questionnaire (mean score = 7.13) did not differ from the normal values of the test (8.51-13.28).

DISCUSSION

Subjects with Raynaud's disease showed significantly higher digital temperatures when exposed to cold after treatment with either classical-conditioning procedures or a combination of biofeedback and relaxation training. Both treatments appear to be equally effective based on digital-temperature data. The subjective reports from subjects indicate that classical conditioning had affected a reduction in painful attacks compared to treatment with biofeedback. The results also suggest that classical conditioning may have a more enduring effect, as evidenced in the 1-year follow-up survey data. The latter result is consistent with the findings of Keefe *et al.* (1979), who

reported that patients treated with biofeedback and/or autogenic therapy returned to baseline after 1 year. These findings are possibly attributable to the failure by the subjects to practice relaxation procedures consistently.

The data presented here give further support to the findings of our earlier research (Jobe *et al.*, 1982) and also support the results of Melin and Fagerstrom (1981). In the present study, subjects were given 54 conditioning trials, with a mean increase in digital temperatures from the pretest to the posttest of 3.9°C. In our earlier study, subjects received 27 conditioning trials and the improvement averaged 2.2°C. Thus, the increase in the number of treatments results in nearly double the increase in the digital temperature. Although it is unclear at this point what the upper limit of improvement might be, the maximum would be that obtained by fully dilated circulation to the hands. As in the previous study, a 1-year follow-up indicated that the conditioning treatments had long-lasting effects.

The present results are also consistent with our earlier work (Jobe *et al.*, 1982) in that no differences were found between subjects with Raynaud's disease and test norms for two measures of emotional stability. Thus, there appears to be no basis, at least in our estimation, for the conclusion that patients with Raynaud's disease are emotionally unstable as a group (Winsor, 1959).

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