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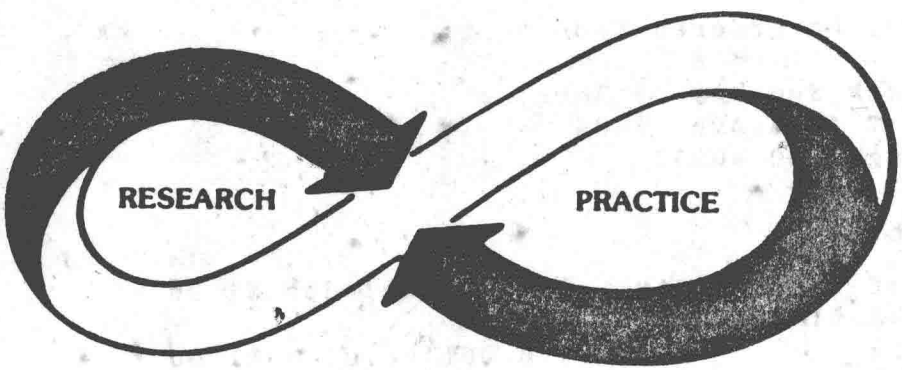

PROCEEDINGS

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AN ASSESSMENT OF DISPOSABLE EMG ELECTRODES IN FRONTAL AND FOREARM APPLICATIONS

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The number of surface recording electromyographic (EMG) electrodes available for rehabilitation and stress management feedback systems are numerous. Therefore, specific evaluation of electrode characteristics for use by both professionals and consummers is essential to insure accurate and reliable signal detection during training periods.

There are many factors that affect the accurate measurement of a bioelectric event at the level of the surface electrode and integumental areas. When metallic electrodes are placed on the skin, an electrolytic compound should be used to establish an ohmic communication with the underlying body fluids (such as secretions from the sebaceous glands, micro-organisms, etc). In the case of dry electrodes, the underlying medium would be that which is produced by the skin layers themselves. These electrodes are quite artifact prone, take substantial periods of time to stablize, and frequently yield high impedance contacts with the skin. Therefore, their application in measuring EMG for stress reduction is not advised until furthur technogical advances are made.

The electrolytes used today are often in a paste or jelly form; and should contain NaCl in a concentration within the range found in human sweat. The concentration usually recommended is 0.05M, for this is sufficient enough to depress silver ion concentrations to the required levels for a optimal surface/skin interface connection.

The importance of NaCl in the electrolytic medium becomes more visible when one looks at the rationale for using silver-silver chloride (Ag-AgCl) electrodes in bioelectric recording. These electrodes consist of a metal in contact with a gel or paste solution containing its own ions. This will facilitate maintenance of a constant ionic environment preventing changes in the local half-cell potentials, and thus limiting an artifact source. In the case of Ag-AgCl, the reversible reaction, $Ag^+ + e^- = Ag$, is controlled by the presence of an adequate concentration of chloride ions in the electrolytic medium, which depresses silver concentration in the vicinity of the electrodes. Thus, use of a modern recessed "nonpolarizable" metal/metal-halide electrode with a paste containing the same halide ion, provides a more constant concentration of ions at the interface.

Recently, technology developed by NASA has led to a flexible biomedical electrode for electromyographic

applications. These electrodes are reported to be comfortable, uniformly conductive, and conform to body countours. The electrode is made by impregnating an elasticized nylon cloth with silver particles.

In this study, four different disposable EMG electrodes that passed an initial screening procedure, and were evaluated for such characteristics as impedance, ease of application, adhesive factor, subject comfort, and skin reaction. An initial screening procedure which involved meeting certain size (for frontal placement) and adhesive characteristics for proper use with EMG instrumentation disqualified six electrodes from further evaluation. Among these six were the newer conductive polymer membrane electrodes. The remaining electrodes that warranted testing included: 1) pre-gelled silver-silver chloride (Ag-AgCl), 2) non-gelled Silver (Ag), 3) non-gelled stainless steel and 4) silver impregnated fabric electrode developed by NASA.

The initial impedance measurements were taken approximately 30-to-90 seconds after electrode application using a Grass Instruments Impedance Meter. All electrodes were equally spaced (15mm) and placed on either the frontal or forearm regions, which were prepared with a **hearty 10** second alcohol scrub with no abrasion **(total N=13)**.

All impedance readings were above 100K ohms when no electrolytic gel was added to the metal or fabric surfaces (including the pre-gelled Ag-AgCl sensors). Satisfactory impedance readings (under 15K) for the Ag-AgCl electrodes were only obtained when an electrolytic gel was dabbed on the metal surface. Dabbing the Ag-AgCl surface with regular water or isotonic salt water did not sufficiently lower impedance as indicated by the accompanying instructions. Therefore, these electrodes will only demonstrate good impedance readings when the pre-gelled surface is dabbed with electrolytic gel **(See Table I)**.

The silver electrodes consistantly demonstrated satisfactory impedance measurements on frontal locations with electrolytic gel added. Even when too much gel was added, these electrodes did not form an ohmic bridge, nor did they lose their adhesiveness. The stainless steel electrodes had impedance values that were barely acceptable and tended to form ohmic bridges if too much gel was added (also comprimising adhesiveness).

All non-fabric electrodes had impedances above 100K ohms when used on forearm locations. However, the silver impregnated fabric electrodes generally had impedance values less than 100K ohms when used in these same areas.

Final impedance measurments were taken approximately 60-to-90 minutes after the initial readings. All frontal sensors demonstrated significantly lowered impedance values probably due to increased electrolyte saturation and stabilization between the electrode/electrolyte/skin

interfaces.

All subjects reported no discomfort after electrode placement. Removal of the frontally placed electrodes elicited some complaints in three of thirteen subjects used in testing the silver electrodes. It is important to note that upon removing the Ag-AgCl electrodes, the pre-gelled surface appeared to stick to the skin resulting in thin strands that could potentially end up in a users facial or scalp areas (eyes, mouth, hair). This reaction did not occur when the electrode was pre-prepped with a little electrolytic gel. The fabric electrodes offered no subject discomfort, even upon removal from hairy areas.

None of the subjects demonstrated a negative skin reaction as would be evidenced by reddening, swelling, itching, etc.

The adhesive factor, for all but the stainless steel electrodes, was excellent. Both the silver electrodes and Ag-AgCl electrodes had enough adhesive strength to make their application on even slightly hairy areas potentially painful upon removal (especially the silver electrodes). Since the fabric sensors were attached to a velcro band, adhesive pressure could be easilly controlled. (See Table II).

Comparative studies assessing the characteristics of disposable EMG electrodes used in biofeedback are practically non-existant. Misconceptions such as the notion that a pre-gelled electrode can give low impedance readings "without the mess and bother of an electrolytic gel" have not been substantiated. Perhaps, in a effort to standardize electrode performance, the society should request data pertaining to manaufacturers claims and make recommendations accordingly.

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TABLE I

IMPEDANCE AVERAGES

Feature	Ag-AgCl	Ag	Silver Fabric	Stainless Steel
Impedance no gel added	>100K	>100K	>100K	>100K
Frontal Impedance gel added	14K	18K	NA	28K
Forearm Impedance gel added	>100K	>100K	64K	>100K

Satisfactory Impedance Readings <25K ohms
Instrumentation Upper Limit = 100K ohms

TABLE II

ELECTRODE FEATURES

Feature	Ag-AgCl	Ag	Silver Fabric	Stainless Steel
Appearance	+++	++	++	+
Ease of Application	++	+++	+++	-
Adhesive Factor	+++	+++	+++	+
Subject Comfort	++	++	+++	+++
Skin Reaction	None	None	None	None

- = poor
+ = satisfactory
++ = very good
+++ = excellent

PSYCHOLOGICAL AND FUNCTIONAL MEASUREMENT IN SEVERE RHEUMATOID ARTHRITIS BEFORE AND AFTER PSYCHOPHYSIOLOGICAL INTERVENTION: A CONTROLLED EVALUATION

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Statement of Problem

According to the Arthritis Foundation (1981), arthritis is the number one crippling disease in the United States. Weiner (1976), reports that the majority of all arthritis patients under the age of 45 are those with rheumatoid arthritis (RA). Five million individuals in the United States have RA. Little is known about the etiology of this disease. However, it is known that RA may manifes as a chronic and degenerative disease. This deterioration may affect many aspects of life, including psychological and functional activities. RA is seen as a sizeable health problem in the United States.

Medical treatment within a multidisciplinary team approach has been the recent standard by which to treat the RA patient. More recently, psychophysiological approaches as an adjunct to the standard medical regimen have been utilized. Psychophysiological treatments utilized include relaxation training, biofeedback, and cognitive-behavioral approaches to chronic pain. These approaches have a logical basis with regard to the maintenance of the RA condition. For instance, chronic muscle tension in and around the joint areas may exacerbate the arthritic condition. Also lysosomal activity in the inflamed joints may be differentially responsive to thermal biofeedback (Pegg, Littler, and Littler, 1969). Finally, the behavioral manifestations which accompany chronic pain may be amenable to cognitive behavioral interventions. Thus, it makes sense to consider these treatments when working with the RA patient.

The following study utilizes both a within groups and a between groups design in order to assess the effectiveness of a psychophysiological approach to the treatment of RA. An active treatment group was compared to a wait-list control group. Both groups received pre and post assessments. The treatment consisted of progressive relaxation training, thermal biofeedback, and cognitive-behavioral approaches to the treatment of chronic pain. Both groups monitored pain, sleep, and medication indices for a ten week period. For the purpose of this study, psychological and functional test measures from the pre and post assessment will be used.

Subjects

The participants in this study were 18 Stage II and Stage III RA sufferers. There were nine subjects in each group. There were eight males and one female per group. All of the subjects were either inpatients or outpatients at the Albany Veterans Administration Medical Center- Albany, New York. All of the patients were referred

to the study by the rehabilitation medicine and/or rheumatological services of the Albany V.A.M.C.

Method

All of the subjects met with the principal investigator for the initial assessment. At this time, a detailed arthritis history was administered. Additionally, the following pencil and paper inventories were administered: a) Beck Depression Inventory, b) State-Trait Anxiety Inventory, c) McGill Pain Questionnaire, d) MMPI, and e) Functional Activities Questionnaire. Following the completion of these inventories all of the patients were shown how to monitor pain, sleep, and medication indices on pre-printed arthritis diaries. At the conclusion of this portion of the initial assessment, all of the patients were escorted to the Physical Therapy service for some further assessment. These physical therapy measures consiseed of range of motion, grip strength, and a timed walk.

At the conclusion of the initial assessment, patients in the wait-list control group were instructed to monitor pain, sleep, and medication indices for a period of 10 weeks. The patients in the active treatment group were asked to return to the hospital in two weeks, in order to begin treatment. Treatment consisted of twice weekly meetings for the first four weeks. Then once per week meetings for two weeks. Two weeks after the last treatment session, patients in the active treatment group returned to the hospital for a post-treatment assessment. Thus, all of the patients in each group had a pre assessment, followed in 10 weeks by a post assessment.

Results

All of the data has been collected, and is in the process of being analyzed. Complete results will be available for presentation at the Seventeenth Annual Meeting of the Biofeedback Society of America. Preliminary observations indicate that significant changes will be noted on the functional measures. The expected significant results will be a main effect of groups, trials, and a group by trials interaction. It is not expected that significant differences will be noted on the psychological test measures.

Discussion

RA is a chronic degenerative disease. Chronic pain, swelling, and discomfort are frequent features of RA. The RA patient lives with this chronic condition expecting little relief. Although it appears that self-regulatory strategies may have little effect on pain ratings, they do appear to have an effect on functional indices. This may be due to the patients perceived sense of control over his body and symptoms. This perceived sense of control is based on self-report, and a cognitive questionnaire. It seems that this sense of control extends into functional aspects of the patients daily life, making certain tasks less difficult.

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A Pilot Study–Comparing the Effectiveness of Two Different Visual Feedback Modalities for Training EMG to Criterion

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Computers, because of their precision, speed, efficiency and bright, colorful displays are attracting much attention in the professional arena and are becoming highly marketable as tools of biofeedback. In the past, visual biofeedback was displayed by colored lights or with a light bar. Now, there are several forms of computer graphics which can display feedback to clients. However, the efficacy of the computer displayed feedback over other modes of visual feedback has not been established.

The purpose of the present study is to evaluate the effectiveness of two different types of visual feedback for future applications with a deaf population. Computer–assisted graphics and a light bar display were used as feedback in training EMG reduction to a stringent criterion level.

EMG biofeedback is used to train relaxation and reduce muscle tension in clinics across the country yet, the criterion at which learning occurs has not been established. There is some retrospective research supporting the fact that there tends to be a therapeutic advantage to training EMG to stringent criterion levels, less than or equal to 1.1 microvolts (Libo & Arnold, 1983). They found that of the clients who reached a detected averaged EMG of 1.1 mv or less, 93% were still improved at follow–up. Therefore, the second aspect addressed by this study is to determine whether training EMG to 1.0 microvolts or less is an achievable criterion for young, normal adults.

METHOD

SUBJECTS

Subjects were 10 normal hearing students enrolled in a graduate level psychology course at the University of the Pacific in Stockton, California. Their mean age was 25 years. The subject pool included those with some previous relaxation training experience (1 male and 3 females) and those without any previous training (2 males and 4 females). All subjects were randomly assigned to one of the two feedback groups.

APPARATUS

EMG level was detected and presented to each subject in one of two forms of visual feedback; a light bar display or a computer graphed display. Auditory feedback was not given. Silver/silver chloride electrodes were placed on the anterior temporalis and EMG levels were measured using the J & J M-53. Integration time was .5 seconds and a narrow band pass filter was used. EMG levels were recorded at 30 second intervals.

Light Bar Feedback

The J & J L-220A Dual Analog Light Display was one mode used to display visual feedback. This mode provided continuous visual feedback of muscle tension. Threshold was gradually lowered as the subject met criterion. Range was set at 0-10 microvolts.

Computer Feedback

The J & J M-53 with the J & J I-300 computer interface was used to produce feedback. The feedback, a time line graph with a chart similar to an oscilliscope was displayed on the Commadore 64. Range was set at 0-10 microvolts and offset was set at 0. Feedback was displayed by a small red airplane moving across the screen at a level proportional to EMG. The airplane left a trace or record of the EMG activity on the screen for a ten second trial. A "cloud" bar was displayed across the screen representing the mean EMG of the previous trial. This was used as a gradual shaping mechanism. Below 2.0 microvolts, the "cloud" bar was absent. At the bottom of the screen, the mean of the microvolt levels of the previous trial was numerically displayed, as well as the EMG level every .5 seconds.

PROCEDURE

Baseline session began with a 3 minute recording from the anterior temporalis of subjects while relaxing with their eyes open. In an attempt to compensate for differing levels of experience with relaxation among our subject pool, the subjects were then introduced to diaphramatic breathing for approximately 3 minutes. Next, they were instructed to listen to a progressive relaxation tape (22 minutes long), again with their eyes open. And lastly, 3 more minutes of baseline was recorded. Baseline and feedback session protocol was the same for all subjects. Also, as an attempt to help equate the subjects knowledge of techniques useful in reducing muscle tension, all subjects were reminded throughout the sessions to; 1) concentrate on diaphramatic, rhythmic breathing, 2) relax their jaw, 3) use autogenic phrases, 4) not to

compete with the machine. All subjects were given verbal feedback, "good job" once they reached threshold and at the end of each session.

Each biofeedback session consisted of a 2 minute baseline and 15 minutes of visual feedback. No auditory feedback was given. Subjects were instructed that the goal of the training was to reach a criterion EMG of 1.0 microvolts or less and maintain that level for 2 minutes. Once the criterion was met, the sessions were terminated. If they could not reach criterion, feedback was terminated after the tenth session. There was a maximum of 9 training sessions, a total of 2hrs. 15mins. of biofeedback.

If individuals had not reached criterion by the end of the ninth session, a tenth session was administered. This session was conducted to assess whether any additional learning would occur as a function of auditory progressive relaxation instruction. It included a 3 minute baseline, listening to the progressive relaxation tape, and an additional 3 minute baseline taken at the end of the session. A follow-up was conducted 2 weeks posttreatment for each subject in which EMG recordings were taken for 15 minutes to determine if maintenance had occurred.

RESULTS

At baseline, the mean EMG for the light bar group was 2.12 microvolts and 1.88 microvolts for the computer group. These means were not significantly different, $p<.66$. There was no main effect for the EMG levels before and after the progressive relaxation tape, although it was approaching significance, $p<.06$. The interaction of the two groups from baseline to post administration of the progressive relaxation tape within the first session did not produce a significant main effect. However, it also approached significance at $p<.06$.

The study is currently in progress. The means of the last 5 minutes for the subjects' last session were taken for each group. The light bar group mean was 1.42 microvolts and the computer group mean was 1.51 microvolts. It should be noted that the average number of sessions for the two groups at this point is different. The mean number of sessions for the light bar group is six and the mean number of sessions for the computer group is four.

Two subjects have reached criterion and feedback has been terminated. One subject in the computer group achieved criterion within 2 sessions and it was maintained at follow-up. One subject in the light bar group reached criterion in 8 sessions. Follow-up for this subject has not been completed.

DISCUSSION

Both forms of feedback appear to be effective in training EMG reduction below 2.0 microvolts. Only 2 subjects thus far have been able to reach criterion; which shows that EMG training to less than or equal to 1.0 microvolts with eyes open is difficult if not an unachievable task, even for young, normal adults.

The subjects of the computer group tended to lower EMG after the auditory presentation of progressive relaxation than the light bar group, and are maintaining at approximately this level during biofeedback sessions. This may only be a function of having fewer number of training seesions. Anecdotally, the subjects in the computer group have reported that visually tracking the graph across the screen interferes with relaxing at such low levels and they prefer to fixate on the numerical readout of EMG at the bottom of the screen. They also report that the graph which is not located on an axis or anchored numerically is ambiguous.

Those subjects in both groups who have not reached criterion within 9 sessions will listen to a second playing of the progressive relaxation tape during a tenth session. It remains to be seen if auditory instructions or the series of progressive relaxation exercises could further reduce EMG. If the auditory instructions are found to be additionally instrumental in reducing EMG, then one would expect that a deaf population may experience difficulty in reducing muscle tension because of their inability to use audition.,

At this point, it is difficult to determine which form of feedback facilitates EMG training with eyes open to such a stringent criterion. It will be necessary to have collected and analyzed all of the data to determine which of these two types of feedback expedites learning.

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Libo, Lester M., Arnold, Georgie E. (1983). Does Training to Criterion Influence Improvement? A Follow-up Study of EMG and Thermal Biofeedback. Journal of Behavioral Medicine, Vol. 6(4), 397-464.

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The Effects of the Addition of a Cognitive Therapy Component to the Home-based and Clinic-based Self-Regulatory Treatment of Vascular Headache

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While there have been several convincing demonstrations of the value of cognitive therapy in the treatment of tension headache, much less systematic research has been reported on the use of cognitive therapy procedures with vascular headache. In the present study we have evaluated the value of adding a cognitive therapy component to a well proven self-regulatory program for vascular headache which combines training in progressive relaxation with thermal biofeedback.

In addition to the above issue, we have also sought to evaluate whether the cognitive therapy component can be added to our successful, minimal therapist contact, largely home-based self-regulatory treatment for vascular headache. Finally, all of the treated groups have been compared to a headache monitoring control group.

Subjects: The participants in this study consisted of 17 males and 54 females who were diagnosed by the Ad Hoc Committee criteria as suffering from either migraine (n=34) or combined migraine and tension (n=37) headache. They ranged in age from 21 to 67 with a mean age of 40.2 years. They had suffered from chronic headaches for an average of 17.7 years.

Method: All patients kept a headache diary throughout their involvement in the study. In it patients recorded, four times daily, their level of headache on a 0 to 5 scale. The diary has been shown to be a socially valid measure of headache. Patients kept the diary for at least four weeks prior to treatment and for four weeks after treatment. The average headache activity score from these two periods were used to evaluate treatment effects.

Treatments: Office-based Self-Regulatory Treatment consisted of 16 sessions (2 per week for 8 weeks) in which the patient initially was taught progressive relaxation, including relaxation by recall and cue-controlled relaxation. In session 7 thermal biofeedback for hand warming was introduced and continued for 8 sessions. Patients received an audio tape to assist home practice of relaxation and a small alcohol thermometer to aid home practice of hand warming.

Home-based self-regulatory treatment consisted of three office sessions (weeks 1, 4 and 8) and a set of manuals and audio tapes to teach relaxation with a similiar thermometer for home biofeedback training.

Office-based self-regulatory training and cognitive therapy. To the office based regimen described above was added a cognitive stress coping training. This was integrated into the 16 sessions and patients were taught to identify negative and stressful cognitions associated with headaches, and modify these cognitions.

Home-based self-regulatory training and cognitive training. Patients were given manuals instructing them in the procedures of the office-based stress coping training. They were seen at weeks 1,2,3,5, and 8.

Headache monitoring control. These patients were seen for the initial assessment, instructed in the use of the headache diaries and then told to monitor their headaches for the next 12 weeks. They recieved no active treatment.

Results: The mean headache index for pre-treatment and post-treatment baselines for all five groups are listed in table 1. Initially we performed a 2 X 2 X 2

repeated measures ANOVA (treatment condition (cognitive vs. non-cognitive) X treatment type (home vs clinic)) on the headache index. All groups showed improvement in their headache activity as measured by their pre-post headache indices. No two-way interaction effects were noted for treatment type or for treatment condition and there was not a significant three-way interaction. There was a significant pre-post main effect ($F(1,39) = 15.73$, $p = .0003$).

To look at our different treatment groups compared to the headache monitoring group, we did an one-way ANOVA for treatment condition on the change scores (pre headache index - post headache index), and followed this up with four planned comparisons (each treatment group with the headache monitoring control). The results show no significant differences among the groups ($F(4,66) = .942$, $p = .45$). In looking at the planned comparisons with the headache monitoring control only the clinic-based cognitive group approached a significant difference ($t(66) = 1.64$, $p = .11$). The other treatment groups were not significantly different from the wait-list control.

Discussion: The addition of the cognitive component to our treatment regimen did not significantly improve our results, as measured by the headache index over the relaxation and biofeedback treatments already being offered. The results from the comparisons with the headache monitoring control group are of potentially more interest. None of the four treatment groups did significantly better than our control group, and only one of the four approached significance level. This result though surprising at first glance could possibly be explained by the method we chose of comparing the groups namely the mean headache index.

When one examines outcome on an individual subject basis using our clinical criteria for success, a percent improvement ((pre-treatment index - post-treatment index)/pre-treatment index) greater than 50%, we find that while 23 out of 43 (53.5%) of the treated patients met this criteria, only 7 of 28 (25%) of the headache monitoring control patients did ($X [1] = 4.53$, $p < .05$). The treatments are clearly superior to the headache monitoring control group using this method of analysis.

These results are preliminary. However, they indicate with our small samples a lack of effect of adding a cognitve therapy component to a self-regulatory treatment for vascular headache. Larger samples are needed to confirm this finding.

Interestingly, 25% of vascular headache patients improve substantially with only headache monitoring. This type of individual subject analysis has not been presented previously for vascular headache patients in a headache monitoring control condition.

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