SPECIFICITY OF BIOFEEDBACK IN THE TREATMENT OF HEADACHE

Carol Solyom

A Thesis

in

The Department

of

Psychology

Presented in Partial Fulfillment of the Requirements

for the degree of Doctor of Philosophy at

Concordia University

Montréal, Québec, Canada

May 1981

ABSTRACT

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Carol A.E. Solyom, Ph.D.
Concordia University, 1980

The main hypothesis of this study was that tension headache subjects would benefit most from E M G biofeedback while migraine headache subjects would benefit most from temperature biofeedback. A hypnotic induction technique which served as a control for the assumed relaxation and home practice aspects of the biofeedback programmes was expected to lead to a lesser degree of improvement, while a waiting list group was expected to show no change.

Patients diagnosed as suffering from either tension or migraine headache were randomly assigned such that there were ten tension and ten migraine headache subjects in each (E M G or temperature) biofeedback group, and five tension and five migraine headache subjects in the hypnotic induction and waiting list groups, respectively. Thus, there

was a total of sixty subjects. A baseline period of four weeks was followed by five weeks of treatment, twice weekly sessions for feedback and once weekly for hypnotic induction, and eight weeks of follow-up. The biofeedback procedures employed (electrode placement, at home practice, etc.) were based on prototypes which have been widely administered in the treatment of headache, except that autogenic instructions were not part of the temperature feedback training programme. The hypnotic induction programme had been used in the treatment of chronic pain, including headache, and in studies with only headache subjects.

Response to treatment was independent of type of headache. In the E M G group, regardless of headache types, 65% of the group reported greater than 50% improvement in headache index (frequency x intensity x duration / week). In the temperature biofeedback group, 88% reported greater than 50% improvement; a significantly greater proportion of the group than in the E M G biofeedback group ($p < .03$). In the hypnotic induction group, 80% reported greater than 50% reduction in headache index; the proportion improved did not differ significantly from either E M G or temperature biofeedback groups. By contrast, only 20% of those on the waiting list reported the same degree of improvement; significantly less than any treatment group ($p < .003$). Frequency of headache attacks was reduced in both E M G and temperature biofeedback and in the hypnotic induction group significantly more than in the waiting list control ($p < .01$). Intensity of headache decreased significantly in all groups, including the waiting control ($p < .007$). There were no statistically significant differences between the groups on other outcome measures of headache.

During the feedback and transfer of training phases of the treatment sessions, E M G levels decreased significantly over time for both E M G groups (Migraine - EMG and Tension - EMG) and the hypnotic induction groups ($p=.007$; $p=.003$, respectively). The differences between the groups were statistically significant during transfer of training sessions with the hypnotic induction group showing larger decreases than either E M G group. The increases in skin temperature during feedback were maintained through the transfer of training phase but none were statistically significant. E M G levels or skin temperature readings did not change significantly from baseline to posttreatment assessments. E M G levels decreased by 12.5 μv in Migraine - EMG, 3 μv in Tension - EMG, 2.8 μv in Hypnotic Induction and 2.7 μv in Waiting List groups. The mean differential temperature increased by $0.1^{\circ}F$ in Migraine - temperature, $1.5^{\circ}F$ in Tension - temperature, $0.5^{\circ}F$ in Hypnotic Induction and $0.9^{\circ}F$ in waiting list groups. Changes in E M G or skin temperature did not correlate significantly with changes in any outcome measures.

The hypothesis of specificity of effect of each biofeedback technique in the treatment of headache was not supported. Both E M G and temperature biofeedback led to a reduction of headache complaint in both tension and migraine headache patients. Equally effective, and at lesser cost, was the hypnotic induction procedure. The effective ingredients of all techniques appear to be the development of a coping skill and the practice of its application beyond the confines of the laboratory.

ACKNOWLEDGMENTS

The warm encouragement, advice and support of Jane Ledingham and Campbell Perry of Concordia University, Psychology Department during all phases of this research are gratefully acknowledged.

The on-site guidance and support of John Davis, of St. Mary's Hospital, Department of Psychiatry, was invaluable and greatly appreciated.

The medical staff of St. Mary's Hospital, Montreal was extremely helpful in referring patients for this study.

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Interest in headache as a disorder amenable to psychologic intervention has increased markedly during the past decade. Major factors in this growth of interest have been developments in biofeedback technology and theory (Budzynski & Stoyva, 1969, 1973; Sargent, Green & Walters, 1972, 1973) and in behaviour therapy (Mitchell & Mitchell, 1971) coupled with a recognition that headache is not solely a "physical" phenomenon (Bakal, 1975) and is frequently not responsive to physical interventions, the most common being a variety of medication.

Classification of Headache

Headache can be symptomatic of a variety of disorders and has therefore been classified into a number of categories (American Medical Association, 1962; Dalessio, 1972) to aid in the selection of effective therapy. For those headaches which are symptomatic of organic disorders, such as systemic disease, space-occupying lesions (e.g. brain tumour) and head trauma, the therapy is directed at the underlying disorder and falls within the expertise of the neurologist or physician. Although they constitute about 10% of headaches (Friedman, Note 2), it behooves any therapist to rule out these types of headaches before initiating non-medical treatment.

The remaining 90% of headache complaints fall into three categories, namely (1) vascular headache of migraine type, (2) muscle contraction headache and (3) combined headaches.

Vascular Headache of Migraine Type. Is characterized by recurrent attacks varying in intensity, frequency and duration. The headache is commonly unilateral in onset, often associated with anorexia, nausea and

vomiting, and often preceded by or associated with sensory, motor and mood disturbances. The pain is described as throbbing, pounding or pulsating. The migraine attack is a two-stage syndrome: intra-cranial arterial constriction thought to produce the various prodromal signs is followed by arterial dilatation which produces the pain. Varieties of these headaches include:

a) Classic migraine, which has sharply defined, transient visual and other sensory and motor prodromes and is almost always unilateral in distribution;

b) Common migraine, where a striking prodrome is absent, is often bilateral in onset and frequently related to environmental, occupational, or menstrual variables and therefore is often called atypical migraine or sick headache;

c) Cluster headache, which is predominantly unilateral and usually associated with flushing, sweating, rhinorrhea and increased lacrimation, occurs in short-lasting attacks of close-packed groups separated by long remissions; and

d) Hemiplegic migraine and ophthalmoplegic migraine, characterized by sensory and motor phenomena which persist during and after the headache.

Muscle Contraction Headache is described as an ache or sensation of tightness, pressure or constriction, about the head. It varies in intensity, frequency and duration, is sometimes long lasting and commonly suboccipital. It may be associated with the sustained contraction of frontalis, occipitalis or temporalis muscle, usually as part of the individual's reaction during stress. The headache thus produced is often

referred to as tension, psychogenic or nervous headache.

Combined Headache: Vascular and Muscle Contraction Headaches are combinations of vascular headaches of the migraine type and muscle contraction headache, prominently co-existing in one attack. They are often referred to as "mixed" headache (Adler & Adler, 1976; Diamond & Franklin, Note 1).

Because of their popularity among patients and in the literature, the terms migraine headache for classic and common migraine and tension headache will be used throughout this presentation.

Some of these headaches seem not to be symptomatic of organic disorder but instead appear to be of functional origin (Horton, 1963). Patients with such headaches often do not derive benefits from medical intervention or are unwilling to tolerate the side effects of medication and thus, psychological intervention becomes a necessary alternative or adjunct to medical treatment.

Headache-specific psychologic interventions have been recently developing but are as yet inadequately tested. Most outcome studies have presented data on a particular treatment of a particular type of headache and have neglected to appraise the same treatment on a different headache type and vice versa. This is most apparent in the biofeedback studies. E M G frontalis or occipitalis biofeedback (Budzynski, Stoyva & Adler, 1970; Budzynski, Stoyva, Adler & Mullaney, 1973; Haynes, Griffin, Mooney & Parise, 1975; Hutchings & Reinking, 1976) is recommended for tension headache; training in hand-warming with temperature biofeedback (Sargent, Green & Walters, 1972) is proposed for migraine headaches;

and a combination of these treatments is suggested where there is a "mixed" headache (Medina, Diamond & Franklin, 1976; Diamond & Franklin, Note 1). This separation of headache types by modality of biofeedback treatment parallels the pharmacotherapy approach which administers ergotamine derivatives for migraine and a combination of analgesic and minor tranquillizer / sedative agents for tension headache. The basis for treatment selection derives from the physiopathology of headache as either a vascular or skeletal muscle disorder.

Development of Biofeedback for the Treatment of Headache

If the headache is a consequence of muscular contractions, then training the headache sufferer to reduce or eliminate muscle tension should reduce or eliminate his headache. Acting upon this logical analysis, Budzynski and Stoyva (1970) treated five subjects suffering from tension (i.e. muscle contraction) headache with E.M G frontalis biofeedback. Within 3 - 4 weeks the patients demonstrated a decrease in both E M G levels (from 5.7 μv to 3.5 μv) and headache intensity (from .80 to .27 headache intensity was rated on a zero to 5 point scale every waking hour and a mean hourly average for each week was calculated). Two of the five patients were headache-free. Continuing with a controlled study involving eighteen subjects, six in each of three conditions - E M G feedback, false feedback and no treatment but weekly contact - Budzynski , Stoyva, Adler and Mullaney (1973) reported again that E M G frontalis feedback training decreased E M G

activity levels significantly more than did pseudo-feedback ($p < .05$) and reduced headache intensity significantly more than the attention placebo and pseudo-feedback control procedures ($p < .001$).

The biofeedback modality suggested for migraine (vascular) headaches was arrived at serendipitously. During studies of physiological functioning in migraine headache patients, Sargent, Green and Walters (1972) noted that increased blood flow, as indicated by a 10°F increase in skin temperature of the hand, coincided with termination of the patient's migraine headache. The possibility of a connection between the increase in hand temperature and reduction of headache served as an inducement to two migraine sufferers to volunteer for training in hand-warming. The training comprised visual feedback of skin temperature changes and the use of autogenic techniques ("my hand is warm and heavy") to assist in hand-warming. In one subject, migraine was eliminated and in the other, markedly reduced. Subsequently, seventy-five other headache sufferers were trained in hand-warming (Sargent et al., 1972, 1973; Sargent, Walters & Green, 1973). Based on a global clinical judgement of one investigator and assessment of graphic records by the other two investigators, the authors reported a 74% improvement rate for the migraine patients. These enthusiastic reports led to widespread use of the technique and a host of similar studies (Cf. Adler & Adler, 1976; Andreychuk & Skriver, 1975; Beasley, 1976; Bild, 1976; Blanchard, Theobald, Williamson, Silver & Brown, 1978; Friar & Beatty, 1976; Graham, 1974, 1975; Johnson & Turin, 1975; Kewman,

1978 and many others).

Development of Biofeedback

Arising from basic research with animals in the early sixties (Miller, 1969), biofeedback has developed into a treatment procedure for a variety of human psychological and physiological disorders (behavioural medicine). The term biofeedback refers to the closed loop formed when information regarding biological functioning is electronically monitored and fed back to the subject. Heart rate, for example, is monitored on an oscilloscope and the activity displayed to the individual on a T.V. screen or information about frontalis E M G activity is provided via a tone that varies in pitch in proportion to the amount of muscle activity. Regardless of the response being measured, the biofeedback training procedure is based on operant conditioning and includes the following components:

1) Continuous measurement of some physiological function;

2) Provision of a signal which can be detected and understood by the subject;

3) Immediate feedback to the subject of changes in that function;

4) An ability to vary the sensitivity of the feedback signal in order to shape the response in the desired direction (Tarler-Benlolo, 1978).

The reinforcement for change in behaviour is considered to be the feedback itself or, more specifically, success in achieving a goal. In individuals with a behavioural or psychological disorder, reinforcement may be improvement in the disorder and the expectation of the improvement may act as an incentive to continue the training.

In a review of clinical applications of biofeedback, Blanchard and Young (1974) concluded that "only in the area of electromyogram feedback for muscle retraining, elimination of subvocal speech while reading and elimination of tension headache does the evidence support strong conclusions on the clinical efficacy of biofeedback training (p.573)." Findings in other clinical areas, including temperature feedback of migraine headaches, were thought by the authors to be based on too little controlled data to allow for any conclusions. However, lacking effective treatment, other clinicians have pursued the hope that biofeedback will prove beneficial in alleviating psychophysiological disorders.

Physiologic Responses of Normals to Biofeedback Training

The idea of applying biofeedback techniques to clinical problems assumed an ability, at least in normal subjects, to acquire control over physiologic functioning. Unfortunately, controlled studies on healthy subjects are accumulating slowly and with contradictory findings. Most disappointing is the inability of Miller and his co-workers (Miller, 1975) to replicate their earlier findings that autonomic functioning could be operantly conditioned. These animal studies had spurred the initial biofeedback applications. In the human laboratory, some studies have found biofeedback training superior to other techniques in the acquisition of physiological control but other studies report negative findings.

With regard to the biofeedback modalities used for the treatment of headaches (i.e. E M G and skin temperature) healthy subjects were able to acquire learned control over E M G frontalis activity

(Budzynski & Stoyva, 1969; Coursey, 1975; Mehearg & Eschett, Note 5) and skin temperature of the hand (Keefe, 1975; Keefe & Gardner, 1979; Roberts, Kewman & McDonald, 1973; Roberts, Schuler, Bacon, Zimmermann & Patterson, 1975; Sheridan, Boehm, Ward & Justesen, 1976; Surwitt, Shapiro & Feld, 1976; McDonagh & McGinnis, Note 4; Taub & Emurian, Note 9, 10). It was, in fact, Budzynski and Stoyva's work with E M G (1969) in normals that led to their work on the use of E M G biofeedback for tension headaches (Budzynski, Stoyva & Adler, 1973).

Budzynski and Stoyva (1969) reported that frontalis E M G biofeedback produced lower levels of muscle action potential in fifteen normal subjects than did simply telling subjects to relax or giving them irrelevant feedback. The same researchers (Budzynski & Stoyva, 1973) later showed that providing masseter E M G feedback also resulted in significantly greater decreases in masseter muscle activity than did a steady tone, irrelevant feedback or non-feedback control procedure. In a similar study, Kinsman, O'Banion, Robinson and Staudenmayer (1975) demonstrated that subjects who received auditory E M G biofeedback decreased their frontalis muscle tension more than subjects who received no feedback or only post-trial verbal feedback of frontalis muscle relaxation. Several other studies (Coursey, 1975; Haynes, Mosley & McGowan, 1975; Reinking & Kohl, 1975) also showed biofeedback procedures to be more effective than relaxation procedures in reducing E M G levels. By contrast, Mohr (1976) and Staples and Coursey (1975) found the two types of procedures to be equally effective in reducing frontalis muscle activity. In all of these studies involving normal subjects, initial E M G levels tended to be low, making it difficult to achieve

further reduction.

Like the initial E M G levels, skin temperature in normal subjects is already close to optimal, leaving little margin for change so that the magnitude of temperature change is small in all studies. In many studies with healthy subjects, the effects of temperature feedback training are confounded by the use of autogenic training (McDonagh & McGinnis, Note 4), hypnotic suggestion (Roberts, Kewman & MacDonald, 1973) and thermal imagery (Taub & Emurian, Note 10). In other studies, however, healthy subjects provided only with feedback and response-specific instructions, were able to produce temperature differences between hand and forehead (Keefe, 1975), between the two hands (Lynch, Hama, Kohn & Miller, Note 3; Roberts, Schuler, Bacon, Zimmermann & Patterson, 1975) and to establish control over absolute temperature changes (Sheridan et al., 1976). Keefe (1975) found that subjects could learn to produce mean decreases in differential finger temperature of 1.5°F and increases of 1.9°F; absolute finger temperature decreased 1.2°F and increased 1.7°F. Keefe and Gardner (1979) reported finger temperature decreases of 2.9°F and increases of 2.5°F.

Physiologic Responses of Patients to Biofeedback Training

Although the magnitude of both temperature and E M G change is small in normal subjects it must be born in mind that healthy subjects begin training with relatively normal values of these parameters. Following the law of initial values (Wilder, 1956, 1962, 1967), changes from this normal baseline should be minimal. Patient populations,

by contrast, typically have extreme levels of these physiological parameters and therefore, might reasonably be expected to respond more readily to biofeedback training.

Patients with tension headaches have demonstrated reduced E M G activity levels after E M G training (Budzynski & Stoyva, 1970, 1973; Cox, Freundlich & Meyer, 1975; Hutchings & Reinking, 1976). Relaxation training, however, led to equivalent decreases in E M G levels (Cox et al., 1975). Control of finger temperature by migraine patients given temperature feedback has been reported by Mitch, McGrady and Iannone (1975) and Turin and Johnson (1976) but neither study included non-feedback programmes. Mullinix, Norton, Hack and Fishman (1978) found that patients receiving true biofeedback obtained significantly greater mean temperature increase than those patients receiving altered feedback signals (irrelevant feedback).

Headache Response to Biofeedback

A summary of studies on biofeedback treatment of headache is attempted in Table 1. There is little uniformity in outcome measures, treatment techniques, concurrent instructions, rating of clinical improvement, etc. Many are anecdotal reports. When a comparison of treatments is carried out (Cox et al., 1975; Haynes et al., 1975; Hutchings & Reinking, 1976) E M G training is effective in reducing headache complaint but usually not better than a relaxation procedure. There is no comparison study of temperature and E M G in treating either headache type.

Table 1

Application of Biofeedback to the Treatment of Headache

Studies on Migraine Headache

Authors	Ss	Training procedure	Sessions / weeks	Concurrent treatment	Physiol. response	Clinical Response: Mean % imp. in headache	Clinical Response: % of pts. rated imp.*	Clinical Response: No. of pts. imp. by % >50	25–49	<25
Sargent, Walters & Green, 1972	32	Hand-warming with differential temperature biofeedback plus autogenic training equivalent to autogenic feedback training	–	Home practice with temperature trainer			80			
Comment: Anecdotal report on 75 pts. Data on improvement available on 32 migraine pts.										
Sargent, Walters Green, 1973	42	Autogenic feedback training	–	Home practice with temperature trainer	–			6	19	17
Comment: Serious faults in methodology and data provided.										
Andreychuk & Skriver, 1975	11	Autogenic feedback training	–	Home practice of technique twice a day	–	"significant reductions" in all groups on headache index (duration x intensity/ weekly average)				
	11	alpha enhancement plus relaxation instructions	10/10							

* criterion of experimenters

Table 1 (continued)

Authors	Ss	Training procedure	Sessions / weeks	Concurrent treatment	Physiol. response	Clinical Response: Mean % imp. in headache	Clinical Response: % of pts. rated imp.*	Clinical Response: No. of pts. imp. by % >50	25-49	<25
	11	hypnosis								
Comment: Controlled group study, but inadequate presentation of results.										
Mitch, McGrady & Iannone, 1976	20	Autogenic feedback training	12-24 / 12	Daily home practice with trainer			65% on 2 or or more headache measures: duration, frequency, intensity, amount of medication at 6 mos. F.U. 9/10=90%	11	2	7
Comment: Same faults as Sargent et al., 1973.										
Friar & Beatty, 1976	10	Biofeedback of forehead pulse amplitude	8 / 3	Instructions to apply training in event of an attack	Change in pulse amplitude Forehead .80 of baseline ($p<.003$) Hand .69 ($p<.005$)	Major headache attacks decreased by 45% ($p<.05$)				
	9	Biofeedback of hand pulse amplitude			Forehead .95 (ns) Hand .67 ($p<.005$)	Minimal change				
Comment: A controlled study: concordance between biofeedback response and headache response.										

Table 1 (continued)

Authors	Ss	Training procedure	Sessions / weeks	Concurrent treatment	Physiol. response	Clinical Response: Mean% imp. in headache	Clinical Response: % of pts. rated imp.*	No. of pts. imp. by % 50	25-49	25
Turin & Johnson, 1976		Pretreatment cooling in 3 pts	12 / 6		Temperature decrease for 2 pts.; .35 & .45°C	No improvement				
	7			Practice technique at home						
		Temperature biofeedback (no autogenic instructions)	18 / 9		Temperature increases for all pts.; range .1-1.7°C			4	1	2
Comment: A controlled study with good baselines.										
Mullinix, Norton, Hack & Fishman,	6	True temperature biofeedback			True feedback showed greater temperature increase than altered feedback ($p < .05$)			2	0	4
			6 / 3	Practice technique at home						
	5	Altered feedback						1	2	2
Comment: Controlled study but lacking in physiological data.										
Blanchard, Theobald, Williamson, et al, 1978	10 (13)	Autogenic feedback training				Sig. imp. but for length of intense headache	1 mo. F.U.	7	2	4
							1 mo F.U.	6	3	2
							6 mo F.U.	4	3	3

Table 1 (continued)

Authors	Ss	Training procedure	Sessions / weeks	Concurrent treatment	Physiol. response	Clinical Response: Mean % imp. in headache	Clinical Response: % of pts. rated imp.*	Clinical Response: No. of pts. imp. by % >50	25-49	<25
	10 (13)	Progressive relaxation training	12/6			Signif.imp. on all variables	1 mo.F.U. 6 mo.F.U.	11 9 5	1 2 2	1 2 2
		Waiting list (Ss then added to treatment groups)				Signif.decr. in # of headaches per week				
Comment: Good controlled study but no data on physiological changes are provided.										
Studies on Tension Headache										
Budzynski & Stoyva,1970	5	EMG biofeedback	8-18/4-9	Home practice in relaxation	Mean EMG levels declined from 5.7μv to 3.5μv (p<.03)	Mean hourly headache intensity: 66%	100%	5		
Comment: Five single case studies. Concordance between EMG & headache.										
Wickramasekera, 1972	5	Non-contingent feedback followed by	6		Mean EMG levels no change	Intens. Dur. no change				

Table 1 (continued)

Authors	Ss	Training procedure	Sessions / weeks	Concurrent treatment	Physiol. response	Clinical Response: Mean % imp. in headache	Clinical Response: % of pts. rated imp.*	No. of pts. imp. by % >50	25-49	<25
		true EMG biofeedback	6		6.5μv-2.5μv	63%	79%			
Comment: Reduction in headache incidence without home practice. EMG superior to control.										
Budzynski, Stoyva, Adler & Mullaney, 1973	6	EMG biofeedback			Mean EMG change from: 10.5μv-3.0μv 3.92F.U.	Mean hourly headache intensity post 3mo F.U.	70% 96%			
	6	Pseudofeedback	16/8	Home practice of lab-learned relaxation	9.75μv-6.8μv 8.43μvF.U.	3mo F.U.	13% 20%			
	6	No training			-		7%			
Comment: A controlled study but EMG training effects are confounded by instructions to practice at home. EMG superior to comparison groups.										
Haynes, Griffin, Mooney & Parise, 1975	8	EMG biofeedback			-	Headache Index 5-7mo F.U. ($p < .01$)	75% 86%			

Table 1 (continued)

Authors	Ss	Training procedure	Sessions / weeks	Concurrent treatment	Physiol. response	Clinical Response: Mean % imp. in headache	Clinical Response: % of pts rated imp.*	No. of pts. imp 50	No. of pts. by % 25-49	No. of pts. by % 25
	8	Relaxation instructions	6/3	Home practice of techniques		F.U. ($p<.01$)	82% 100%			
	5	"Relax as much as possible"				F.U.	27% 30%			
Comment: Feedback and relaxation equivalent but superior to control. No concordance between EMG levels and headache.										
Cox, Freundlich, Meyer, 1975	9	EMG feedback, cue controlled breathing plus self-instruction "relax"	8/4		Signif. reduced EMG levels ($p<.001$)	Headache Index	61%	8	0	1
						4 mo. F.U.	69%	7	0	1
	9	Bernstein & Borkovec's (1973) progressive relaxation	8/4	Home practice	Signif. reduced EMG levels ($p<.001$)		57%	4	3	2
						F.U.	70%	7	1	0
	9	Medic. placebo "known to be effective"	4/4				11%	2	3	4
						F.U.	17%	3	1	4
Comment: Feedback and relaxation equally effective, superior to placebo. No concordance between EMG levels and headache. Only study using medication placebo.										

Table 1 (continued)

Authors	Ss	Training procedure	Sessions / weeks	Concurrent treatment	Physiol. response	Clinical Response: Mean % imp. in headache	Clinical Response: % of pts. rated imp.*	Clinical Response: No. of pts. imp. by % >50	25-49	<25
Chesney & Shelton, 1976	6	Relaxation training	3-9 / 2			Relaxation training, biofeedback and combined group associated with signif. greater reductions in headache frequency than control: greatest reduction in headache duration associated with combined and relaxation training groups, combined group associated with greatest decrease in headache intensity.				
	6	EMG biofeedback								
	6	Combined relaxation & EMG biofeedback								
	6	No treatment								

Comment: EMG biofeedback ineffective. No instructions for home practice.

Table 1 (continued)

Authors	Ss	Training procedure	Sessions weeks	Concurrent treatment	Physiol. response	Clinical Response: Mean % imp.* in headache	Clinical Response: % of pts. rated imp.*	Clinical Response: No. of pts. imp. by % >50	25-49	<25
Hutchings & Reinking, 1976	6	EMG biofeedback			Mean EMG decreased from 20μv-8μv 5μvF.U.	50% 1mo F.U.25%				
	6	Relax.inst. (Combination of Jacobson, 1938, Wolpe & Lazarus, 1966 & Schultze & Luthe, 1967)	10	Home practice of lab-learned techniques	20μv-8μv 10μv F.U.	-33% 1mo F.U. 0%				
	6	Combined feedback and relax.			16μv-6μv 5μv F.U.	-62% 1moF.U.-69%				
Comment: Controlled group study. EMG superior to unusual relaxation procedure.										
Epstein & Abel, 1977	6	EMG(music) feedback	16	None	-	-	50	1	2	3
Comment: Equivocal effect on headaches.										
Phillips, 1977	8	EMG biofeedback		-	Mean change in EMG 5.63μv-2.92μv ($p<.05$) 3.59μv F.U.	Intensity 27% 6-8wk F.U. 53% Frequency 30% F.U. 30%				

Table 1 (continued)

Authors	Ss	Training procedure	Sessions weeks	Concurrent treatment	Physiol. response	Clinical Response: Mean % imp. in headache	Clinical Response: % of pts. rated imp.*	No. of pts. imp. by % >50	25-49	<25
	7	Pseudo-feedback		-	4.19μv - 3.71 μv 3.2μvF.U.	Intensity 27% F.U. 0% Frequency 16% F.U. 32%				
Comment: Controlled study. Biofeedback superior to control in reducing EMG levels and headache variables.										
Studies Including Both Migraine and Tension Headache Patients										
Sargent, Green & Walters, 1973	M-20	Autogenic feedback training		Home practice with temperature trainer	-	3 raters agreed on outcome of 19 Ss	12/15=80			
	T-6						2/ 4=50			
Comment: Anecdotal report - no controls, inadequate data.										
Bakal & Kaganov, 1977	M-5	EMG biofeedback	15	Home practice in deep muscle relax.	Mean EMG decreased from 21.5μv-13.5μv (p<.05)	Headache score decreased significantly				
	T-5				10.0μv-7.5μv (p<.05)					
Comment: EMG biofeedback equally effective for both groups.										

Relationship between Change in Physiologic Response and Change in Headache

That reduction in tension or migraine headache symptoms during and after biofeedback is a direct result of learned control over myographic or cardiovascular activity remains equivocal. The correlation between change in E M G activity levels and change in tension headaches ranges from a high of +.90 (Budzynski et al., 1973) to a low of .42 (Cox et al., 1975). Budzynski et al. (1973) reported a negative correlation of .05 for the pseudofeedback group. In an ABAB type design, Wickramasekera (1972) demonstrated proportional decreases in headache intensity and E M G levels during contingent E M G feedback but not during non-contingent feedback training which preceded the contingent feedback. Cox et al. (1975) concluded that reduction in E M G levels accounted for only 18% of the variance of treatment effect and proposed that successful treatment depends not only upon learning E M G control but also upon increased relaxation throughout the patient's daily activities, early recognition of headache onset and adequate early application of relaxation skills in stressful situations.

Not only is the relationship between change in E M G levels and change in headache unclear but the relationship of high E M G frontalis levels to tension headache (Sainsbury & Gibson, 1954), an assumption basic to the use of E M G biofeedback treatment of tension headache, has become suspect. Elevated frontalis E M G activity is not found in all tension headache subjects (Haynes et al., 1975). Those reporting frequent tension headaches had a significantly higher E M G level than those

reporting few or no tension headaches. Haynes et al.(1975), however, also found subjects with frequent headaches who had low E M G levels. Similarly, Epstein and Abel (1977) noted a discordance between E M G activity and mean headache levels in five of six tension headache subjects, and, in the one subject where there was concordance, relatively large changes in E M G during baseline, feedback and self-control phases were accompanied by relatively small changes in self-reported headache. Equally disconcerting was the finding that although all but one subject demonstrated control of E M G during the feedback phase, no subject showed any self-control of E M G activity in the absence of feedback. To complicate matters further, the subject who demonstrated no control of E M G, even during feedback, was among those whose headache improved. Epstein and Abel (1977) also pointed out that their successful subjects showed a baseline frontalis E M G level of below 20 μv thus negating the idea that feedback is effective for patients because of their extreme initial E M G levels. It may be effective because "healthier" or less deviant behaviour is yet plastic and therefore still amenable to change.

In a group of tension and mixed tension-migraine subjects (also with low E M G levels), Phillips (1977) found that biofeedback benefitted both the tension and mixed headache patients but the latter subjects proved to be poorer candidates for E M G biofeedback. Despite higher initial levels of E M G frontalis activity, the mixed headache subjects were less able to use the training to reduce muscle tension and the correlation between muscle tension reduction during feedback and

reduction in headache activity was significantly lower for this group (negative, in fact). Pure tension headache was substantially reduced in those subjects who were able to lower muscle tension level during the voluntary control phase but the reductions became significant only during the follow-up period six weeks later. Phillips also reports that the correlation of muscle tension level and headache intensity was high only for pure tension cases (Phillips, 1977,p.126).

The exact nature of the relationship between biofeedback training and headache is as unclear in the treatment of migraine as it is in the treatment of tension headache. Of the three subjects whom Turin and Johnson (1976) first trained in hand temperature cooling, two showed no change in migraine while the third reported a worsening of her headache. When these and four other subjects were trained to increase finger temperature, all subjects could do so and all seven reported reduced headache activity. Turin and Johnson (1976), therefore, concluded that the effect was directly attributable to hand-warming and not to "placebo" factors which were similar for both conditions. Mullinix et al. (1978), however, concluded that headache improvement was due to placebo factors. Despite a significantly greater increase in skin temperature for the true feedback than for the pseudofeedback group, both groups showed similar improvement in headache. The authors suggested that patient expectation and suggestibility were important factors.

Assumptions Underlying the Use of Biofeedback in the Treatment of Headache

The theoretical relationship between increasing hand temperature and reduction of migraine headaches is less obvious than that between reducing muscle tension and reduction of tension headaches. Sargent et al. (1973) assumed that the migraines are ameliorated because "Patients are learning to turn off excessive sympathetic outflow (p.419)." Migraine symptoms, "part of a stress-related syndrome (Sargent et al.1973, p.418)" develop first in response to vasoconstriction of certain intracranial arteries which probably produce the prodromata and second, to vasodilatation and distention of cranial arteries, primarily branches of the external carotid which cause the pain (Schumacher & Wolff, 1941; Wolff, 1963). The attack on vascular dysfunction in the head by increasing hand temperature is linked with general relaxation of sympathetic outflow which leads to migraine relief. Relaxation of sympathetic activity can be achieved by hand-warming but hand-warming occurs in a "condition of relaxed detachment (Sargent et al., 1973, p.419)." Boudewyns (1976) found that finger temperature decreased under stress conditions and increased under relaxation conditions.

If E M G frontalis biofeedback leads to conditions of relaxation, perhaps E M G feedback would have the same effect on migraines as does temperature biofeedback. Since E M G frontalis levels have been reported to be considerably higher in migraine subjects than in tension headache

subjects (Bakal & Kaganov, 1977; Phillips, 1978; Pozniak-Patewicz, 1976) E M G biofeedback may be more effective than temperature biofeedback. Bakal and Kaganov (1977) report E M G biofeedback, unfortunately preceded by training in deep muscle relaxation, equally effective in reducing migraine or tension headache.

Wickramasekera (1973), reporting on the successful use of temperature biofeedback in the treatment of migraines, referred to his prior lack of success in treating the same two subjects with E M G feedback. Similarly, Epstein and Abel (1977) comment upon the lack of effectiveness of E M G feedback for migraine headache in a subject whose tension headaches had been considerably reduced with this feedback modality.

Hand-warming as a possible treatment for tension headaches, has been given even less consideration than E M G for migraines. If, however, hand-warming is related to relaxation and relaxation is the critical component of effective E M G feedback for tension headache, then temperature feedback for hand-warming may be equally effective in relieving tension headache. On the other hand, if training in hand-warming leads to a decrease in blood flow in the head, tension headaches could benefit since there is increased blood flow in the affected muscles during tension headache (Onel, Friedman & Grossman, 1961).

The Role of Relaxation in the Treatment of Headache

A feature common to many non-pharmacologic treatments of headache seems to be training in relaxation. Sargent et al.(1972), Tarler-Benlolo (1978), Warner and Lance (1975), Tasto and Hinkle (1973), Schultze and Luthe (1969), Hay and Madders (1971) are among several authors

reporting successful reduction in headache following training in relaxation. Transcendental meditation and yoga, which can be construed as programmes of relaxation training, have also been used as treatments for headaches (Benson, Malvea & Graham, 1973).

On the other hand, Mitchell & Mitchell (1971), in a well controlled experiment, reported relaxation training to be ineffective for migraines. If, however, relaxation training was used in combination with systematic desensitization and assertiveness training, migraines were reduced. Besides its use in reducing E M G levels of specific muscles as in tension headache, E M G biofeedback has been used as a general relaxation procedure (Raskin, Johnson & Ronsdestvedt, 1973; Tarler-Benlolo, 1978). The thrust of much of the recent headache research therefore has been to compare E M G frontalis biofeedback with other types of relaxation training such as Jacobson's progressive relaxation , Schultz and Luthe's (1969) autogenic training or a combination of biofeedback and relaxation techniques. Of three comparative studies , two (Cox et al., 1975; Haynes et al., 1975) found E M G biofeedback and relaxation equally superior to control conditions; the third (Hutchings & Reinking, 1976) found E M G superior to relaxation and not enhanced by the addition of relaxation although relaxation also led to reductions in headache complaint. In the Cox et al. (1975) and Hutchings and Reinking (1976) studies, patients were asked, as in the Budzynski et al. study (1973), to practice relaxation at home. It is not clear how much this home practice in relaxation accounts for the results attributed to E M G biofeedback. Haynes et al.(1975)

did not assign relaxation practice at home but simply advised subjects to use the techniques that they were learning either to prevent or terminate the headache.

In many of the temperature feedback studies (e.g. Sargent et al., 1973) both autogenic training and use of a temperature trainer were assigned for home practice. The request to practice at home my be an important aspect of all the programmes since it does suggest to the patient that he take an active role in reducing his headache symptoms. Cox et al. (1975) attribute equal importance to this and factors such as recognizing headache onset and then applying his relaxation skills as well as to reductions in E M G frontalis for achieving good results.

These suggestions fall in nicely with current views of pain as a multifaceted phenomenon - physiological, cognitive and behavioural - the functional relationship of which is crucial to treatment management. Melzack and Perry (1975) emphasize the importance of "all the contributions of (their) training procedures in combination in producing substantial pain relief (p.467)." Hence, the requirement to utilize lab-learned skills at home or whenever a headache strikes suggests to the individual that he is being provided with the means to control headache. The level of perceived pain has been shown to diminish with a sense of control over pain (Melzack, Weisz & Sprague, 1963).The more effective the skill, however, the more likely that the patient will use it. Thus, it is extremely important to determine which technique is best for him. No unequivocal evidence supports change in E M G levels or skin temperature as the factor responsible for headache reduction. There is presently no

evidence for specificity of biofeedback effect. The present study was initiated to determine: 1) If E M G biofeedback is specific for tension headache, 2) If skin temperature biofeedback is specific for migraine headache, and 3) If both biofeedback procedures for the appropriate headache type are better than a non-specific relaxation procedure.

In "The Practicing Physician's Approach to Headache", Diamond and Dalesio (1978, p.138) recommend biofeedback temperature training for "classical" migraine, a combination of temperature training and E M G feedback for non-classical migraine and mixed headache, and E M G training for tension headache. Despite the face validity of this treatment plan, the evidence that these are effective techniques, is scarce. There are confounding variables in many of the reported studies. That it is the biofeedback training and not a number of other "placebo" factors which is responsible for the improvement is not clear, nor has it been adequately demonstrated that the biofeedback technique which seems effective for a particular type of headache (i.e.E M G feedback for tension headache) would not be beneficial for other headache (i.e. E M G for migraines). Combining biofeedback with another technique, such as autogenic training and relaxation, may or may not enhance the outcome with that technique (Tarler-Benlolo, 1978), and if biofeedback or the combination treatment is not better than relaxation alone, then the prolonged and expensive use of biofeedback is unwarranted.

If the relaxation component is the important aspect of either

treatment approach then the biofeedback techniques should be compared with relaxation alone. Thus, both migraine and tension headache patients were assigned to a hypnotic induction programme adapted from Melzack and Perry (1975) and Perry and Melzack (Note 5). Melzack and Perry (1975) had found that this procedure brought about considerable reduction in chronic pain, including headache. Though slightly less effective than a combination programme of alpha-biofeedback and hypnosis, the hypnotic induction alone was more effective than alpha feedback alone, reducing chronic pain by more than a third in 50% of the patients (Melzack & Perry, 1975). In studies with only headache patients, Andreychuk and Skriver (1975) and Anderson, Basker and Dalton (1975) found a similar hypnotic procedure to be beneficial.

The present study on the effect of E M G and temperature biofeedback on migraine and tension headache was undertaken to answer these questions about treatment specificity. E M G biofeedback, the usual treatment modality for tension headache, was administered to subjects with tension headache, and to subjects with migraines. Other migraine and tension headache sufferers were trained in hand-warming with temperature biofeedback.

A group of patients awaiting treatment at a later date served as a control for the effects of monitoring and naturally occurring headache variability. These patients were assessed before and after an equivalent time period. Thus, there are six groups of headache patients:

1) Tension headache subjects trained in E M G biofeedback (Tension - E M G)

2) Migraine headache subjects trained in hand-warming with skin temperature biofeedback (Migraine - temperature)

3) Tension headache subjects trained in hand-warming (Tension - temperature)

4) Migraine headache subjects trained in E M G biofeedback (Migraine - E M G)

5) Tension and migraine headache subjects treated with hypnotic induction / relaxation training (Hypnotic induction)

6) Tension and migraine headache subjects maintained on a waiting list (Waiting list)

Both Tension-E M G and Migraine - temperature groups were expected to show significantly more improvement in headache than all other groups and to demonstrate physiological control which correlates with change in headache. This expectation derived from the hypothesis that the effectiveness of each feedback modality is specific only to the appropriate headache type. Tension-temperature, Migraine- E M G and Hypnotic induction groups were expected to show greater improvement in headache than the Waiting list group but were not expected to differ from each other.

Method

Subjects

Family physicians, neurologists, other medical practitioners in the

same hospital (St. Mary's Hospital, Montreal) were informed of a treatment study being undertaken and were asked to refer patients suffering from either tension or migraine headache. These patients and others who had learned of the programme indirectly (e.g. friends of patients) were screened, including E E G testing, by a physician to exclude those subjects with organic pathology or clinically important psychiatric disorders. The same physician verified the diagnosis of migraine or tension headache. A migraine headache patient had to present with a minimum of of two headaches per month and two of the following criteria: 1) Periodic, unilateral throbbing headache, 2) Nausea and vomiting, and irritability, and 3) Temporary visual or other C.N.S. disturbances preceding the attack. The tension headache patient had to present with: 1) bilateral headaches, described as a dull ache or as a feeling of pressure, and 2) an absence of vomiting.

Family history, personality type, physiological parameters, and psychometric test data, although collected, were not used as selection criteria. The assumption that these data discriminate between tension and migraine headache patients has been shown to be invalid (Phillips, 1978; Waters, 1974; Waters & O'Connor, 1971; Ziegler, Hassanien & Hassanien, 1972).

Tension headache subjects were randomly assigned to E M G feedback training, temperature feedback training, hypnotic induction training or waiting list groups. Migraine headache subjects were randomly assigned

Table 2

Distribution of Subjects

Group	Headache Type	
	Tension	Migraine
E M G biofeedback	10	10
Temperature biofeedback	10	10
Hypnotic Induction	5	5
Waiting List	5	5

Table 3

Group Mean Scores
on Pretreatment Assessment Items

Item	Treatment groups						
	M - EMG	M - temp	T - EMG	T-temp	HYP	WL	ANOVA *
n	10	10	10	10	10	10	
Age	36.4	45.2	30.8	25.4	28.7	33.8	$p<.01$
Sex M : F	1:9	1:9	2:8	3:7	4:5	2:8	
Educ. yrs.	12.7	12.4	13.6	14.0	14.5	12.6	
Age of onset	19.5	22.1	22.1	15.1	17.6	17.7	
Zung	36.8	42.5	45.9	37.0	33.6	44.6	
IPAT sten	5.6	7.4	8.2	6.1	6.4	7.2	.01
MPI - N	13.6	22.1	28.4	23.2	33.5	28.7	.02
MPI - E	25.3	20.0	22.4	27.7	27.0	27.3	.05
CI	19.6	22.7	29.9	17.7	22.0	28.0	

* Source tables for analysis of variance are given in Appendix C, Tables 1 through 6.

to the same groups providing a total of four treatments, each with an equal number of migraine and tension headache subjects. The sixty patients were distributed as outlined in Table 2.

The rationale for the smaller sample size in the hypnotic induction & waiting list group was an ethical one. Since both groups would be receiving less than a total treatment package it was deemed advisable to limit the group size.

Mean age of the patient sample was 33.4 years. Only thirteen of the subjects were male, providing for a preponderance of females in all groups. Mean age, sex distribution and characteristics of the subjects deemed relevant in previously published reports (e.g. Dalesio, 1970) are given in Table 3. The psychometric tests were administered with a view to delineating prognostic indicators as well as to describing the characteristics of the population. The Zung Depression Scale (Zung, 1965) is a self-administered, valid measure of depression which correlates well with other more elaborate depression scales such as the Hamilton (1960) and Beck (1961) Depression Scales. The I P A T Anxiety Scale (Cattell, 1957) measures primarily trait anxiety. Both depression and anxiety are frequent findings in chronic pain states and may also occur in patients with headaches. Their presence could be assumed to be a barrier to patient co-operation and to successful outcome of treatment. The Maudsley Personality Inventory (M P I - Eysenck, 1959) assesses neuroticism and extroversion, variables which may also affect treatment outcome. Cornell Medical Index (C I) as a measure of

general neurotic behaviour may prove to be valuable as prognostic indicator.

Three of the original subjects in this study dropped out and were replaced by other individuals. Two of the three dropouts were males, aged 51 (Tension-temperature) and 69 (Tension-E M G), suffering from tension headache. Both dropped out during the baseline period on the grounds that they were unable to comply with two sessions a week of therapy. The third dropout was a 42-year-old female also suffering from tension headaches (Tension-temperature). She dropped out after four sessions of temperature biofeedback. Up to this point, she had failed to return the treatment headache data. Furthermore, during the session she was unable to increase hand temperature and her resulting frustration led her to quit.

Apparatus

E M G biofeedback was provided by a Bio-Feedback Technology, Inc. Feedback Myograph, B F T -401, which displayed changes in the electrical potential of muscles in the form of a needle deflection on a meter. A Time Period Integrator, B F T 215, used in conjunction with the myograph, measured average level of tension in microvolts. Readings of a 60 second period of integration taken every three minutes yielded a quantitative measure for subsequent analysis.

Training in hand-warming was achieved through the use of a Bio-Feedback Technology, Inc. Feedback Thermometer, B F T 301. The meter displayed the temperature differential between two sites in degrees Fahrenheit, each division representing one tenth of a degree. A digital

dial allowed the instrument to be calibrated in such a manner that in this differential mode, before attaching the thermistors to the subject, a zero baseline on the meter was read in the digital dial as an arbitrary 50 Fahrenheit.

Procedure

Baseline. After medical screening and verification of headache type, subjects were randomly assigned to treatment groups. During the first baseline session, a history of the subject's headaches and the first of two 15 minute baseline recordings of frontalis E M G and finger temperature were taken. All subjects were informed of the purpose and the procedure for collecting baseline measures of headache and physiological activity before starting therapy. Standardized record sheets (Appendix A), noting occurrence, intensity and duration of headache as well as precipitating factors and coping mechanisms used to deal with headache, were given to the patients with instructions to maintain these daily reports over the next four week period.

During the first interview, subjects were also apprised of the different techniques that have proven to be effective in eliminating headaches, and subject's consent to proceed with the programme was obtained. They were given permission to continue taking their usual medications for headache relief but were asked to note the type and dosage taken on the headache report form.

Pretreatment. At the end of the four week baseline period, a second baseline recording of E M G frontalis and skin temperature was taken and treatment initiated. Waiting list patients were told that no treatment

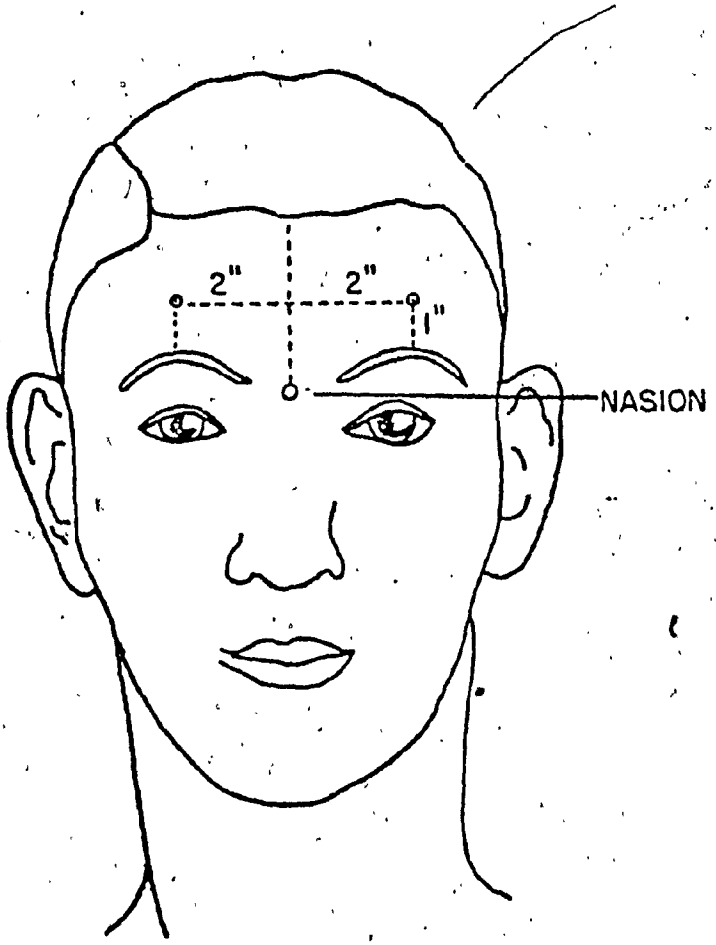

FIGURE 1. STANDARD FOREHEAD LEAD

time was currently available and were asked to continue record-keeping for another five weeks when treatment would begin. All subjects were required to maintain the daily headache reports throughout the treatment (five weeks) and follow-up periods (eight weeks).

Subjects in the biofeedback training groups were asked to come twice weekly. As part of the treatment package which included reduced contact with the therapist but availability of taped instructions for home use, hypnotic induction subjects came once weekly for the next five weeks. Posttreatment assessments were carried out in week five. Thus, biofeedback subjects had eight training sessions, hypnotic induction subjects had four.

Assessment and treatment sessions were carried out with the subject reclining comfortably in a lounge chair.

Treatment. For E M G recording, surface electrodes were positioned over frontalis muscles, according to the diagram taken from Davis (1952) in Figure 1.

During both E M G and temperature biofeedback training, feedback was provided to the subject via needle deflection on a meter. The subjects were told that on the E M G feedback device, needle deflection to the left or zero end of the meter signalled a reduction in muscle activity, while deflection to the right signalled an increase in muscle tension. A demonstration of this relationship was achieved by having the patient wrinkle his or her forehead and then smooth it out. The subjects were told that other individuals had learned to control headache by learning to reduce muscle activity and that they could learn to do the same. They were instructed to use whatever means they could to move the needle to

the left which would mean a reduction in their frontalis muscle tension. The subjects were also asked to practice daily at home the technique they used during the treatment sessions. After two weeks of treatment, it was suggested that they use this technique to abort or prevent a headache before resorting to their usual medication.

For skin temperature recording, two thermistors, one attached to the volar surface of the right index finger and the other to the left temple, provided a measure of the differential temperature between head and hand. A reading of 50 (mid-point zero on the meter) indicated that the two temperatures were equal. During training, the subjects watched needle deflection, with the deflection to the right of the mid-point denoting an increase in finger temperature relative to the head, a deflection to the left, a decrease in finger temperature relative to the head. Subjects in the temperature feedback groups were told that headaches can be aborted by hand-warming and that they could learn to warm their hands by means of the feedback monitor, the needle of which deflects to the right when they are successful. Like the E M G feedback subjects, they were given no autogenic training or any other specific instructions but simply told to try to raise the temperature reading on the meter using any technique other than physical procedures such as rubbing the skin. As in the E M G feedback groups, temperature feedback subjects were asked to practice daily at home whatever technique worked for them in the lab and, after two weeks of training, to use this technique to abort a headache before resorting to their usual medication.

The hypnotic induction group was given the same explanation about the role of tension in headache as were the E M G feedback patients.

They were told that by following the instructions given on the cassette (Appendix B) with which they were provided, they could learn to reduce tension and thus control their headaches. The training began with relaxation techniques focusing on individual muscle groups and controlled breathing. Then followed Hartland's "ego strengthening technique" (Hartland, 1971), suggesting that the patient will feel stronger, healthier, more alert, less tense, more self-confident, etc. and that he then would be able to reduce his own awareness of headache and thereby lessen the pain. The programme that was used by Melzack and Perry (1975) was modified for headache sufferers. The modification followed the procedure of Anderson et al. (1975) who employed Hartland's suggestive therapy (1965) and ego strengthening suggestions (1971) and found the hypnotherapy significantly better than stemetil prophylaxis in reducing migraines. During therapy sessions, physiological parameters were monitored to assess the hypnotic induction patient's ability to relax. The only feedback provided was a verbal report that they were doing well.

Like the subjects in the other treatment groups, hypnotic induction patients were told to practice these exercises at home. Unlike the other patients, however, they were able to listen to the same instructions at home as in the lab.

During each treatment session, subjects were seated comfortably in a reclining chair. Following a short discussion lasting 10 minutes regarding the past week's headache report, subjects were attached to the appropriate apparatus and asked to relax quietly. A session baseline reading, taken over 6 minutes, was recorded. Feedback was then provided to the biofeedback subject who was asked to control needle deflection

in the required direction. This "feedback" phase lasted 12 minutes and was followed by "a transfer of training" phase of 9 minutes during which the subjects were asked to continue either lowering muscle tension or warming their hand as they had done when provided with feedback.

The hypnotic induction subjects were told that the apparatus would give the experimenter an idea of how well they were able to comply with the instructions on the cassette. Following a 6 minute baseline phase, the hypnotic induction tape was played. The E M G and/or temperature readings were made as for biofeedback subjects, broken into equivalent time periods. Tape termination coincided with the last (transfer of training) phase of recording.

Throughout the treatment period, all subjects were asked to maintain the daily reports of headache activity. They were asked to record date and time of each headache, any precipitating factors, duration in hours, and the intensity of pain on a 1 to 5 point scale (where 1 indicated a slight headache and 5, an incapacitating one). The subjects were also asked to to record what action they took to relieve the headache, to note the name and dose of any medication and to assess the outcome of such treatments on a 1 to 5 point scale (where 1 indicated recovery and 5, no change).

Data Analysis

The data were analyzed in three ways for each of the eight groups: 1) changes in amount of headache, 2) changes in physiological parameters, and 3) relationship between changes in headache and changes in E M G

or hand temperature. The statistical methods used included analysis of covariance in which the influence of the covariate is removed by a simple linear regression method thus adjusting for the effects of group baseline values; analysis of variance; t-tests; and Chi Square tests.

Headache was measured five ways - frequency, intensity, duration, amount of medication used and headache index (frequency x intensity x duration). The headache index was devised as a means of measuring overall headache change so that the patient who reports half as many headaches of the same duration and intensity can be compared with the patient who reports no change in frequency of headache but has less severe, shorter lasting headaches. A similar headache index was used by Andreychuk and Skriver (1975). They multiplied "number of hours duration by the severity of the headache rated on a 5-point scale, summing these figures each week, and computing the average weekly rating . . .(p.174)." Other investigators, beginning with Budzynski et al (1970) and including Cox et al (1975), Bakal and Kaganov (1977) and Blanchard et al (1978) have used an hourly average headache activity score. Cox et al (1975) give a formula: "H_D= (I:D)/24 where headache intensity (I), as indicated on a 5-point scale, is multiplied by the hours of headache duration (D); these products being summed for each day and divided by 24, yielding an hourly weighted average of headache activity (p.893)." Phillips (1977) modified this by using number of waking hours rather than 24 as the denominator.

In 1980, Blanchard et al refer to the headache index as " a preferred measure since it tends to combine intensity, duration and

frequency and is thus probably the most sensitive measure of change . . .(p.614)."

An analysis of covariance was performed on all headache measures using the mean baseline value (collected over a four week period) as the covariate. The sources of variance in these analyses consisted of two between-subjects variables - treatment (4 levels) and type of headache (2 levels) - and one within-subjects variable - time (6 levels; weeks 1 through 5 and follow-up).

Changes in E M G and skin temperature from baseline to feedback phase of each session and from baseline to transfer phase of each session were analyzed separately using analysis of variance with repeated measures. Sources of variance consisted of two between-subjects variables - treatment (4 levels) and type of headache (2 levels) - and one within-subjects variable - time (4 levels: weeks 1, 2, 3 and 4). An analysis of variance of change in E M G and temperature from baseline to post-treatment (week 5) was also carried out.

To determine the relationship between change in E M G and change in headache, five one-way analyses of covariance were carried out - one for each of the measures of headache, using change in E M G (post-treatment - baseline score) as the covariate. The only source of variance was type of headache. The relationship between change in hand temperature and change in headache was assessed by performing the same five analyses of covariance, using change in hand temperature (posttreatment score - baseline score) as the covariate.

Results

Treatment groups, both biofeedback and hypnosis, showed equivalent reductions in headache variables. Both were superior to the waiting list control. Physiological control in trained subjects was not demonstrated nor was there a significant relationship between change in physiological parameters and change in headache. There was a trend for change in E M G to be positively associated with change in duration of headache.

Table 4 presents the adjusted mean group scores and Figure 2 plots changes in frequency, intensity, duration of headache, amount of medication taken and headache index from pre-assessment through follow-up for all groups. An analysis of covariance, using baseline measures of the headache variable, thereby reducing baseline variance, was applied to the data. Testing the adjusted covariate removed contaminating factors and was, therefore, a better test than to measure the correlation of the covariate with the dependent variable. This test also gives more reliable results. Raw data for all headache variables are given in Appendix C, Tables 7-11. Source tables for the analyses of covariance are given in Appendix C, Tables 12-21 for changes from pre- to posttreatment and Tables 22-31 for changes from pre- through posttreatment to follow-up.

The biofeedback and hypnotic induction groups decreased the frequency of headache ($F=3.96$; $df=3,47$; $p=.01$) significantly more than the waiting list group over the treatment period and maintained this level at follow-up. Throughout treatment, all groups, including the waiting list group, reduced headache intensity ($F=3.64$; $df=4,192$; $p=.007$).

At baseline, duration of headache was very high for the Migraine-temperature group. Duration is mean number of hours per headache (not

Table 4

Mean Group Scores on Headache Variables at Pretreatment (Covariate) and Adjusted Mean Group Scores on Headache Variables at Posttreatment and at Follow-Up

Groups		M-EMG	M-temp	T-EMG	T-temp	HYP	WL
n							
Frequency[a] (per week)	Pre	3.95	3.68	4.30	4.10	3.42	4.36
	Post	2.53	2.51	2.31	1.54	2.73	4.88
	F.U.	2.05	1.32	2.43	2.03	2.51	
Intensity[b] (1 - 5)	Pre	3.11	3.24	3.04	2.52	2.75	2.92
	Post	1.81	1.66	1.31	1.71	1.36	2.50
	F.U.	2.39	2.37	2.68	2.36	2.27	
Duration (hours)	Pre	13.26	23.53	12.68	9.95	6.39	9.80
	Post	10.08	1.93	8.49	3.48	2.61	9.19
	F.U.	12.45	9.80	14.75	4.94	4.65	
Medication (no. of pills)	Pre	2.80	4.24	3.30	2.24	2.57	2.24
	Post	1.85	0.00	1.76	0.94	0.98	1.74
	F.U.	1.48	2.28	2.55	1.48	1.72	
Headache Index	Pre	103.84	128.69	153.26	93.62	75.77	118.99
	Post	88.52	13.84	54.13	38.14	47.85	117.18
	F.U.	51.06	11.41	38.15	44.08	60.19	

* Mean baseline values used as covariates

a Treatment effect (excluding follow-up) significant ($F=3.96$; $df=3,47$; $p=.01$)

b Time effect (excluding follow-up) significant ($F=3.64$; $df=4,192$; $p=.007$)

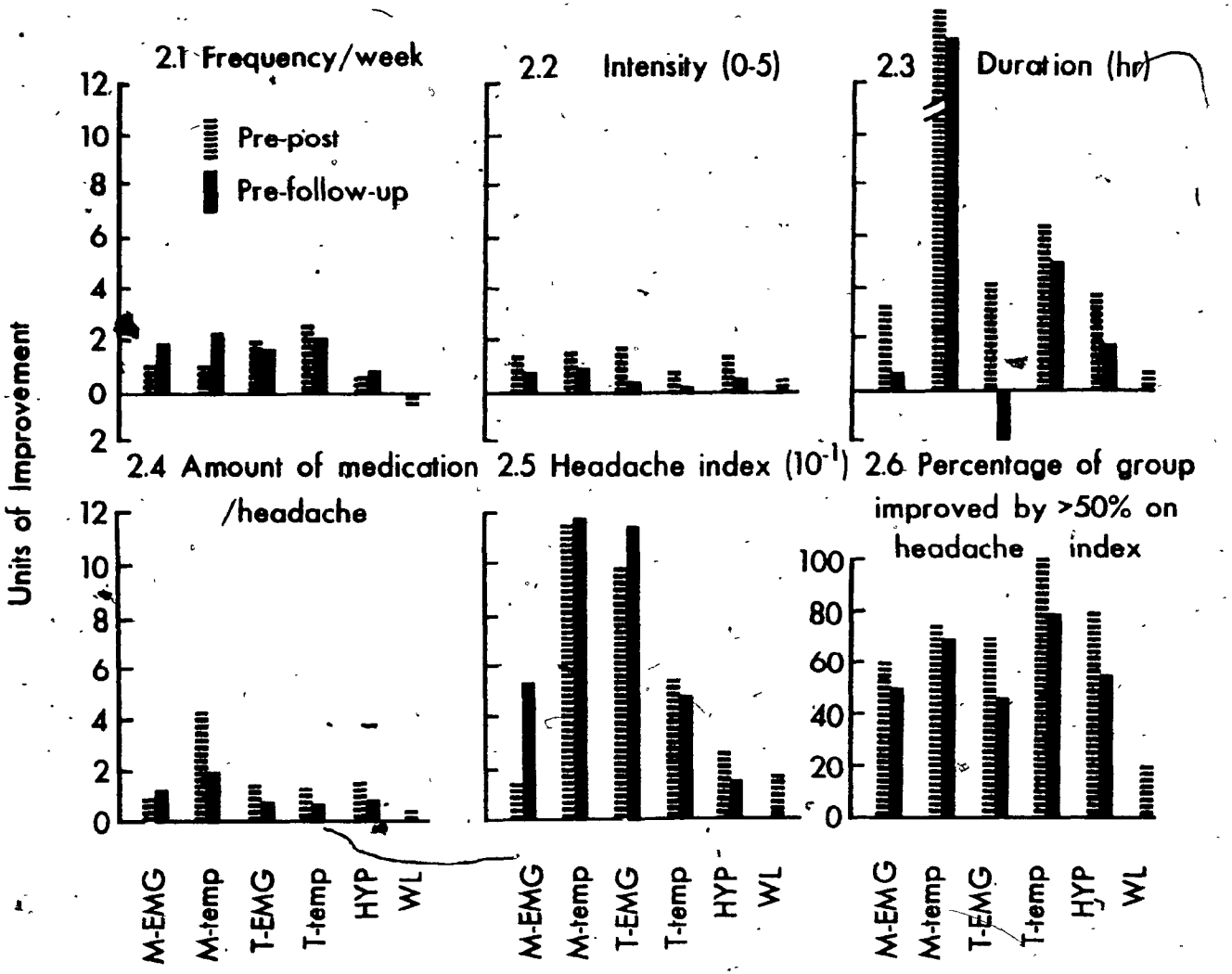

Fig. 2 UNITS OF IMPROVEMENT IN HEADACHE VARIABLES AT POST-TREATMENT AND FOLLOW-UP

per week) and the high score was partly accounted for by two subjects who reported only three headaches each during baseline, but thses were very long-lasting, from 3-6 days (72-144 hours). The hypnotic induction group had much shorter lasting attacks. As can be seen in Fig. 2.3, the temperature biofeedback groups reduced duration of headache somewhat more than did the E M G feedback groups. Differences between groups on headache index changes (Fig. 2.5) are not statistically significant.

Because of the wide variability in headache measures both within group and within subjects, a percentage improvement in headache index score was calculated for each patient (Appendix C, Table 11). The distribution of subjects by percentage improvement in headache index is shown in Table 5. Table 6 lists the percentage improvement for each subject.

On the basis of the assumption that more than 50% improvement in headache index is clinically meaningful but less than 25% is not, a comparison was made between improved (>50%) and non-improved (<25%) groups. A total of 38 patients reported greater than 50% improvement at termination of treatment, 15 reported improvement of less than 25%. The difference between proportions of improved patients across groups was statistically significant (X^2=14.18, df=3,p=.002), which is due, in the main, to the fact that only two patients in the waiting list group improved by more than 50%. At follow-up (which does not include waiting list patients), 29 patients reported greater than 50% improvement; 11, less than 25% (p=.002).

The analysis of variance of E M G change scores (derived by subtracting baseline from posttreatment measures) yielded an almost significant interaction effect (headache type x treatment: p=.057). Analysis of variance rather than covariance was used since reduction in variance was achieved at the individual level by computing change scores. E M G

Table 5

Rating of Overall Status of Patients in Each Group at Termination of Treatment and at Follow-up.

Groups	M-EMG		M-temp		T-EMG		T-temp		HYP		WL
	Post	F.U.	Post	F.U.	Post	F.U.	Post	F.U.	Post	F.U.	Post
n	10	10	8	10	10	9	9	10	10	9	10
Headache-free	4	0	1	1	4	0	3	0	4	1	1
Much Improved (>50%)	2	5	5	6	3	4	6	8	4	4	1
Moderately imp. (25-50%)	0	2	1	1	0	3	0	1	1	1	2
Slightly imp. (1-25%)	1	0	1	2	3	0	0	1	0	2	1
Worse	3	3	0	0	0	2	0	0	1	1	5

Table 6

Percentage Improvement in Headache Index for Each Patient

Patient	M-EMG		M-TEMP		T-EMG		T-TEMP		HYP		WL
	Post	F.U.	Post	F.U.	Post	F.U.	Post	F.U.	Post	F.U.	Post
1	-764	74	42	95	24	33	99	86	26	m*	- 42
2	16	- 11	99	99	74	68	100	43	91	83	28
3	-670	80	59	64	17	33	100	97	100	84	- 380
4	- 13	32	22	11	81	95	74	72	- 125	9	- 33
5	100	- 70	m	20	3	89	100	77	81	35	0
6	64	-361	m	49	100	m	m	0	76	-91	80
7	66	31	100	82	100	72	69	81	100	100	- 228
8	100	79	96	100	100	-139	82	64	100	90	26
9	100	95	78	91	100	-118	52	52	100	18	100
10	100	93	97	98	64	39	75	66	90	80	- 25

m* = missing data

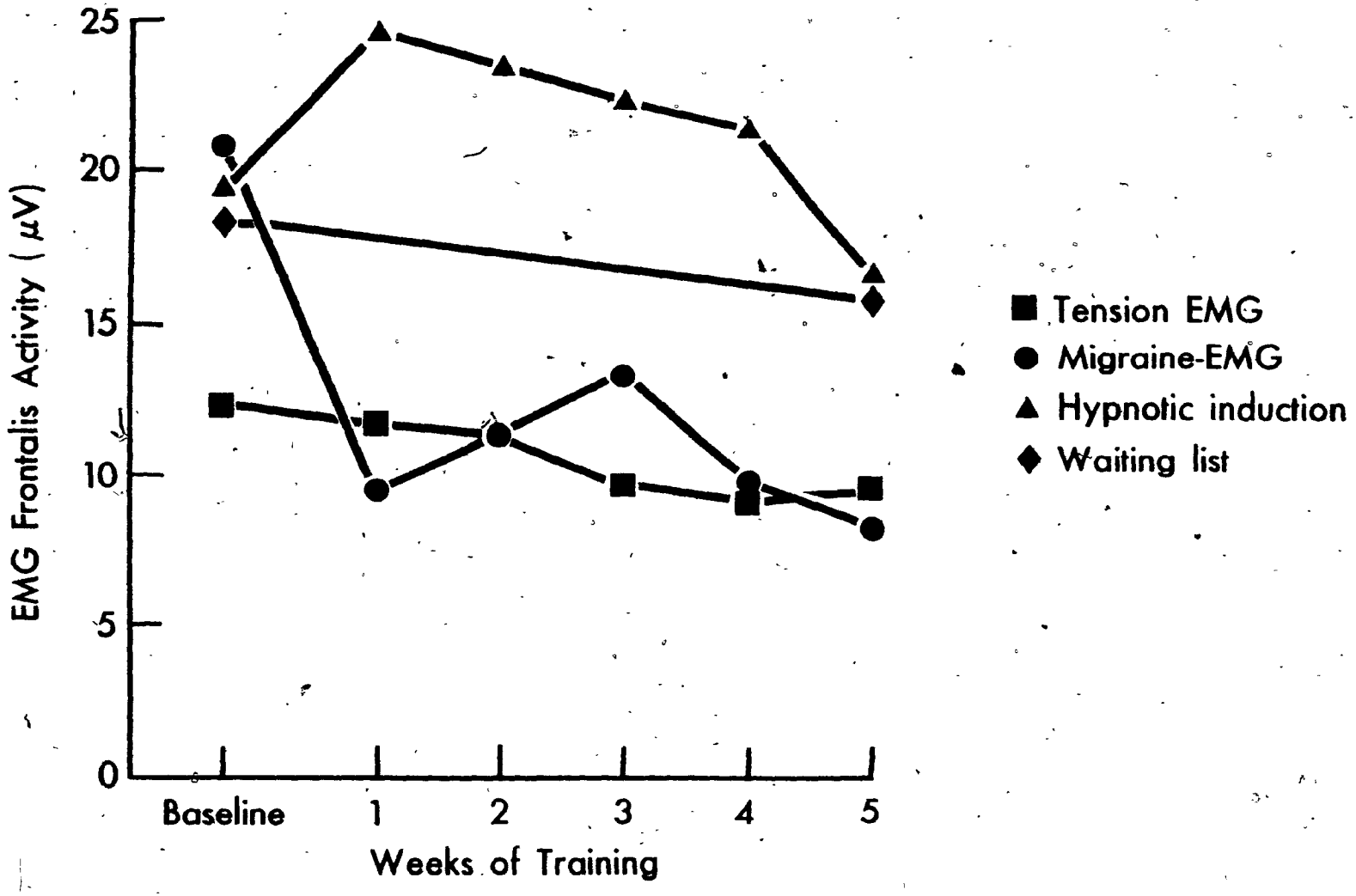

Fig. 3 MEAN GROUP EMG BASELINE ACTIVITY

activity, at baseline and follow-up, with change scores, is given in Appendix C, Table 32. Sessional E M G data are given in Appendix C, Table 33. Source table for analysis of variance of change scores is given in Appendix C, Table 34. Fig. 3 plots mean group E M G activity at baseline and posttreatment sessions and the sessional baselines for E M G biofeedback and hypnotic induction groups.

Within session changes from baseline to feedback and baseline to transfer of training phases (or same time period for HYP group) for each week of treatment are shown in Figs. 4 and 5, respectively. The decrease in E M G level during the feedback phase differed significantly over weeks of treatment ($F=4.39$, $df=3,54$, $p=.007$) with best performance occurring in week 2. Best performance during transfer of training phase also occurred in week 2 ($F=5.33$, $df=3,54$, $p=.003$) with the hypnotic induction group showing the greatest decrease of all groups (interaction of week x treatment: $F=2.86$, $df=3,54$, $p=.045$). For the hypnotic induction group this phase coincided with a period of silence at the termination of the taped instructions. Source tables for analysis of variance of change in sessional E M G activity are given in Appendix C, Tables 35 and 36.

Interestingly, the peak increase of skin temperature in all but the Migraine-temperature group also occurred in week 2. Differential temperature readings at baseline and posttreatment, with change scores, are given in Appendix C, Table 37 and sessional readings in Table 38. The Migraine-temperature group had its best performance in week 3. Fig. 6 shows baseline scores at pre- and posttreatment as well as during treatment for temperature feedback and hypnotic induction groups. The changes

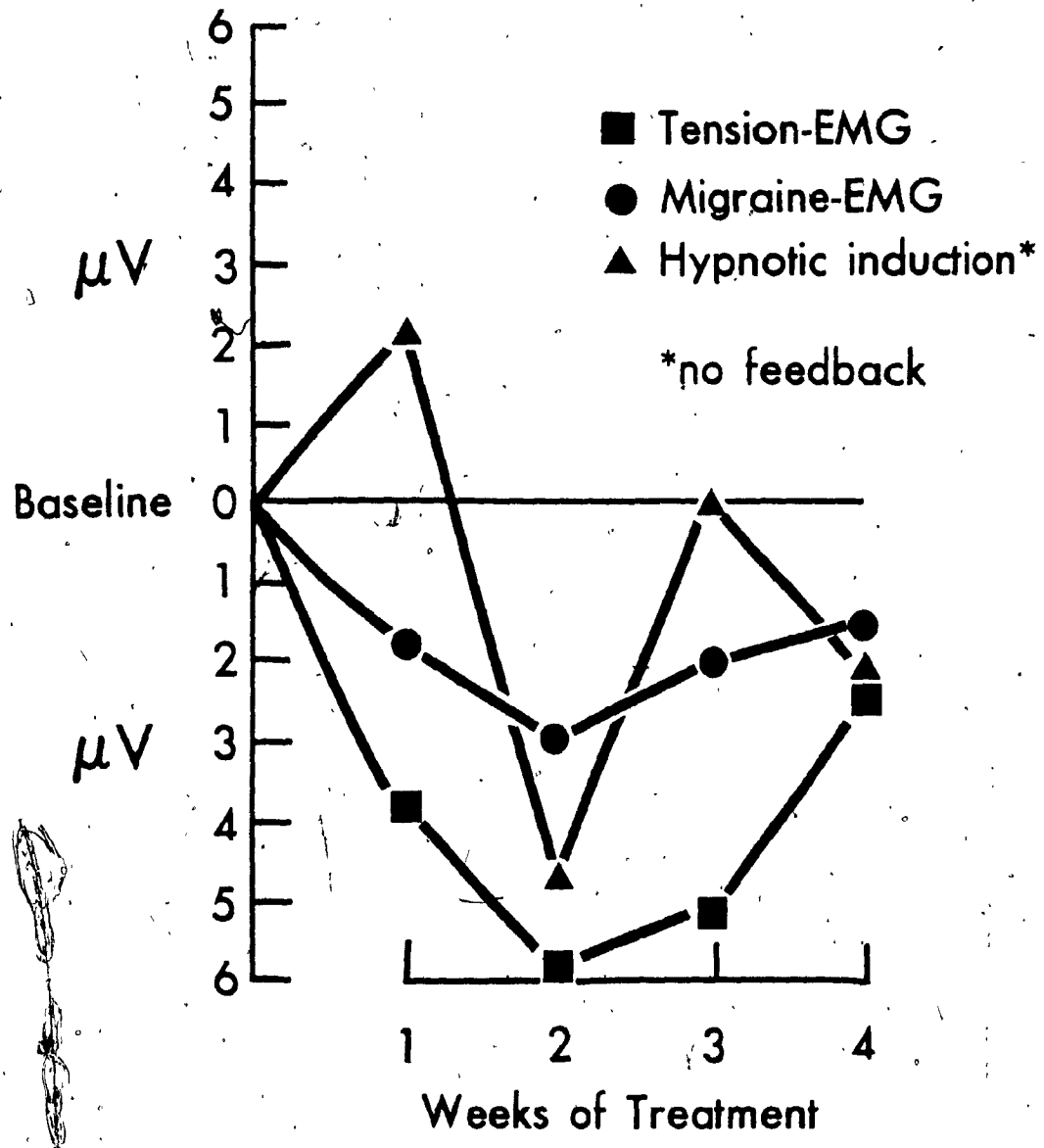

Fig. 4 MEAN GROUP CHANGE IN EMG ACTIVITY FROM BASELINE TO FEEDBACK PHASE

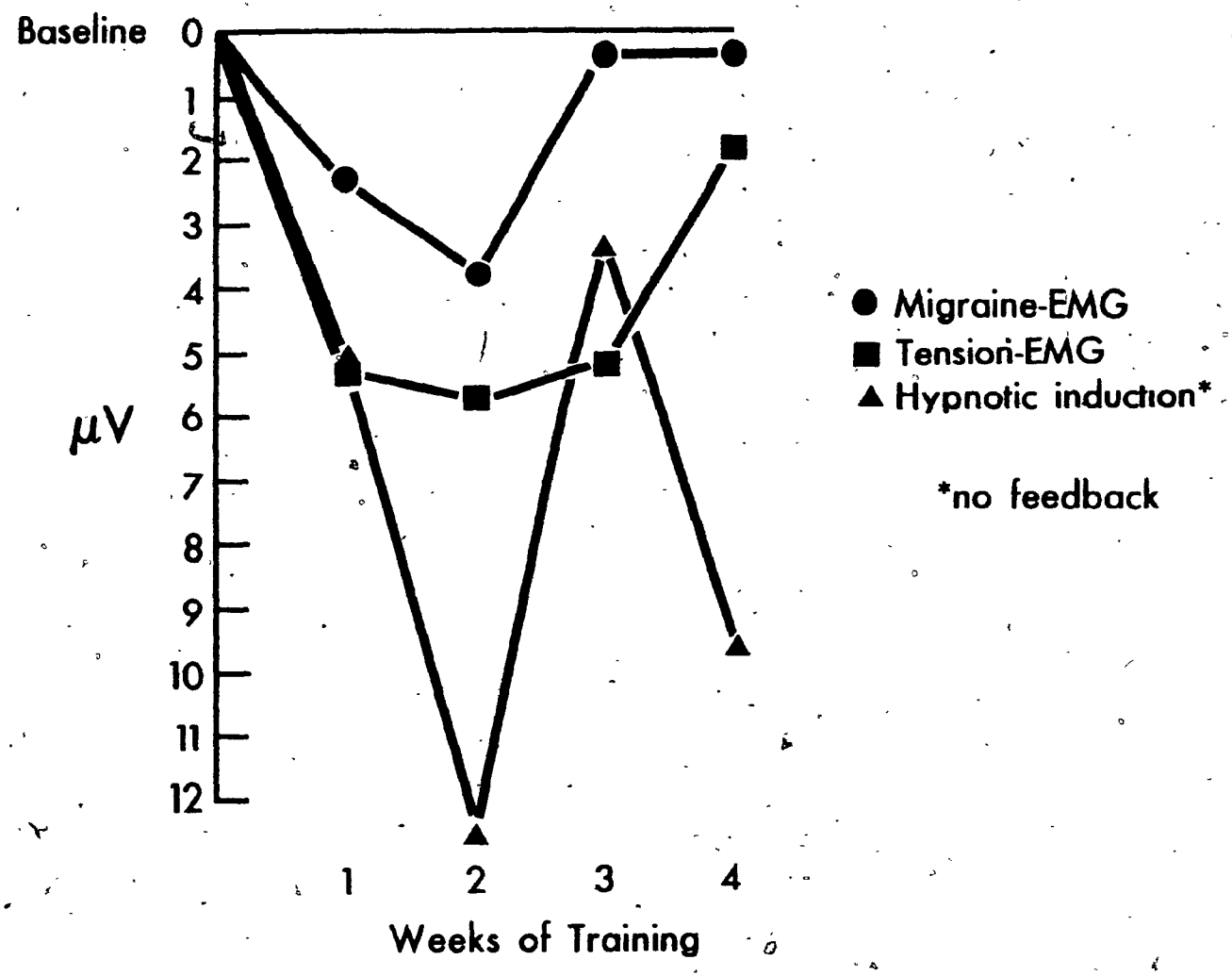

Fig. 5 MEAN GROUP CHANGE IN EMG ACTIVITY FROM BASELINE TO TRANSFER PHASE

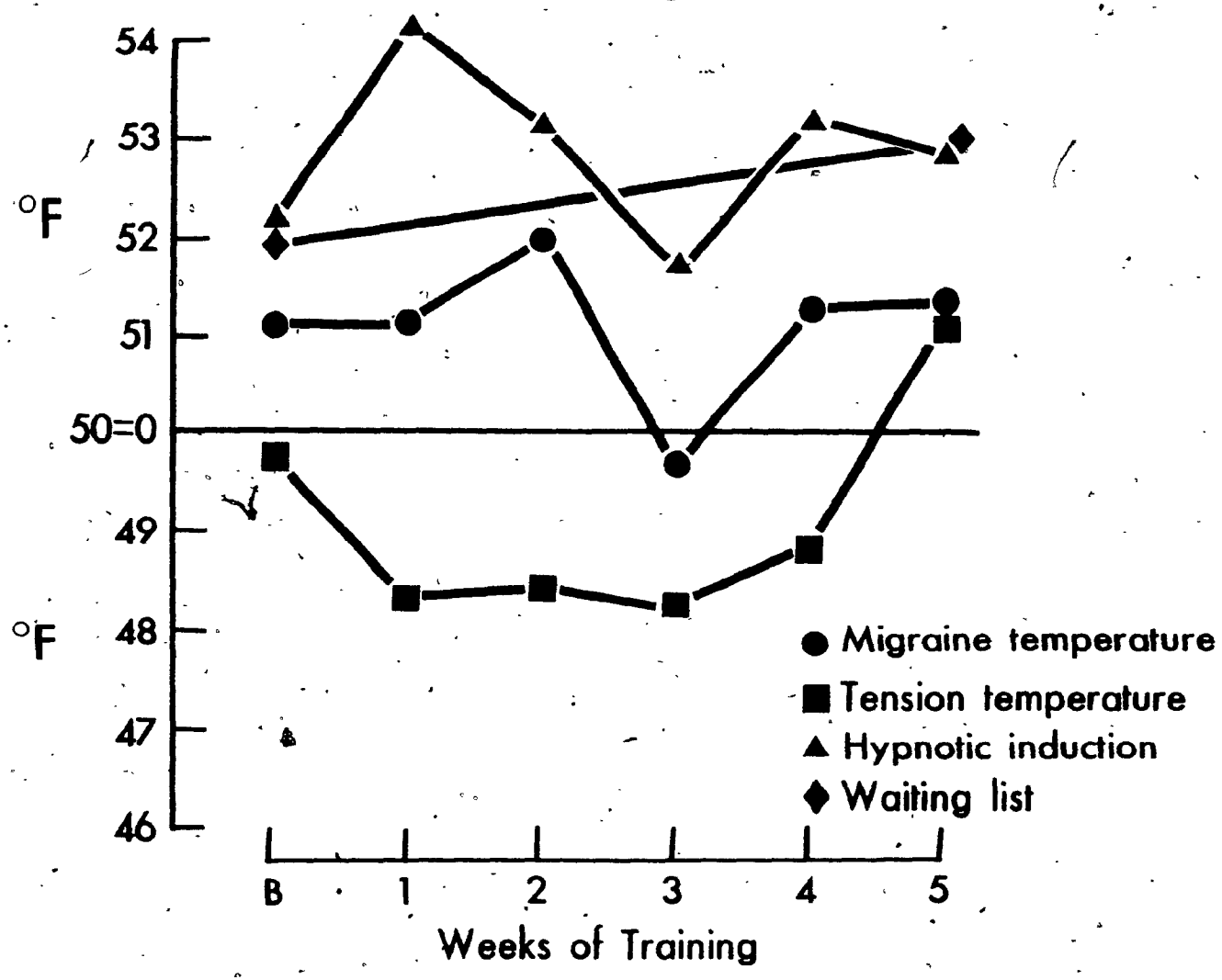

Fig. 6 GROUP MEAN DIFFERENTIAL TEMPERATURE LEVELS

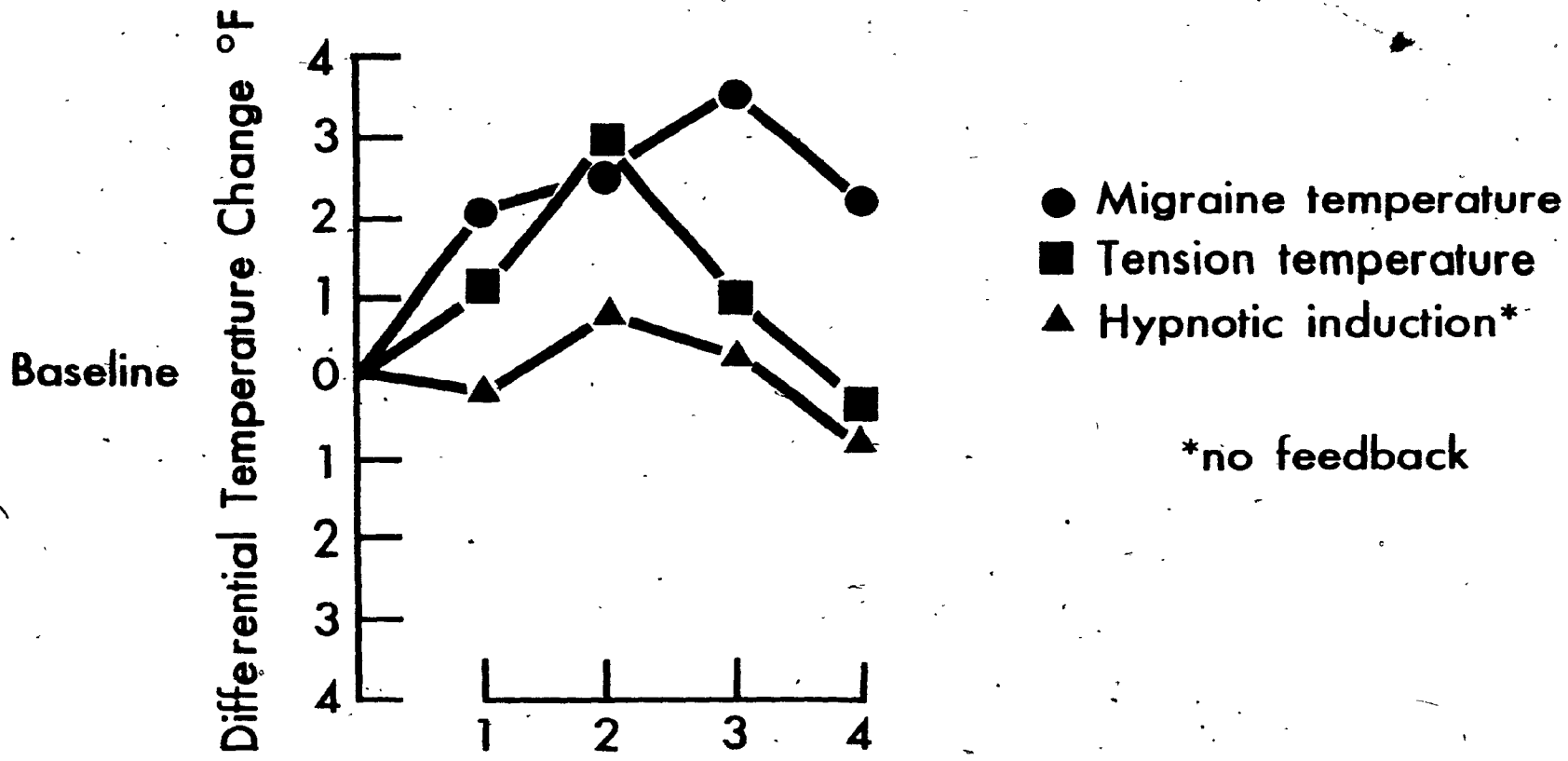

Fig. 7 MEAN GROUP CHANGE IN FINGER TEMPERATURE DURING FEEDBACK PHASE

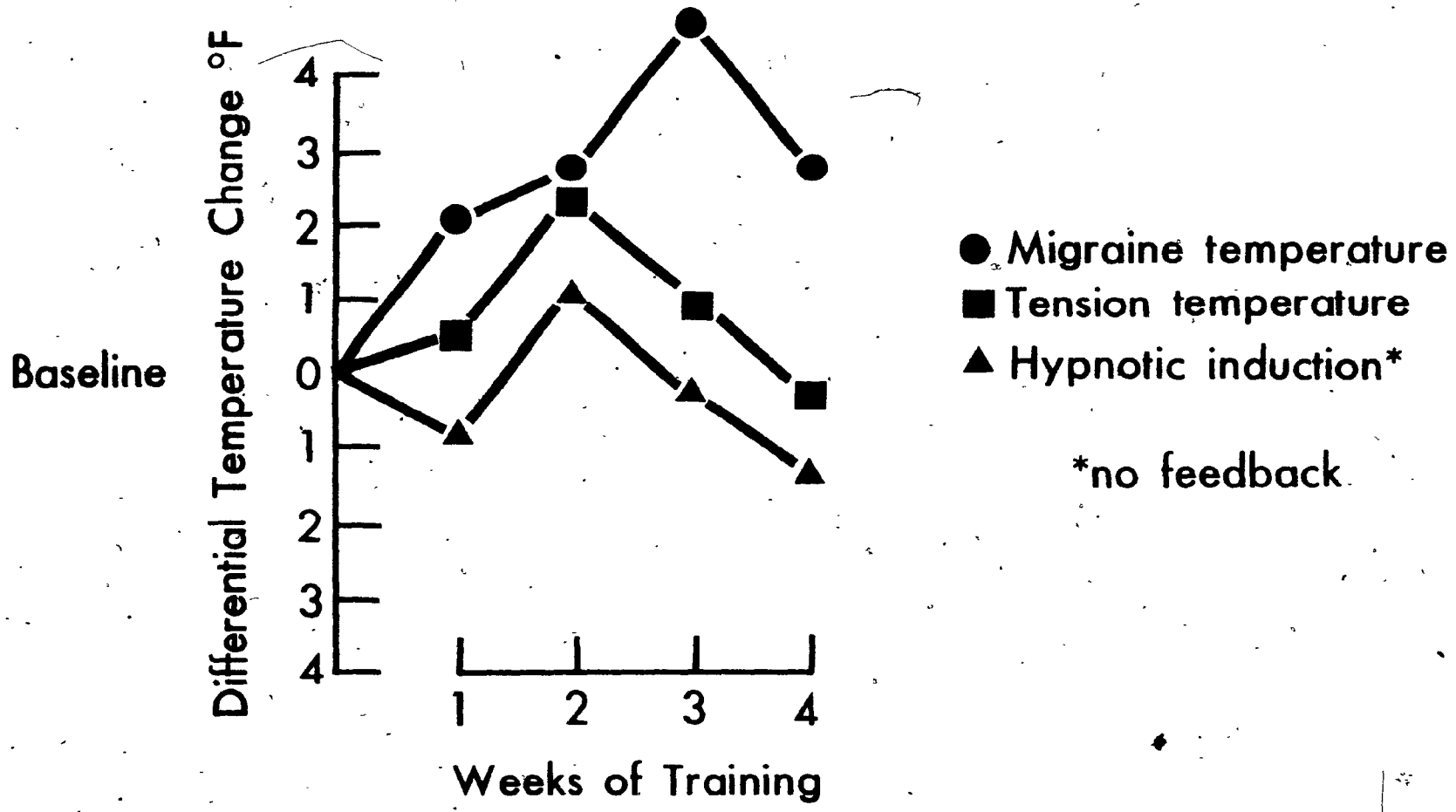

Fig. 8 MEAN GROUP CHANGE IN FINGER TEMPERATURE DURING TRANSFER PHASE

in skin temperature from baseline to feedback and to transfer of training phases for each week of treatment are shown in Fig. 7 and 8, respectively. Changes achieved during feedback were maintained during transfer phase but the changes were statistically nonsignificant. Source tables for analysis of variance of change in temperature are given in Appendix C, Table 39, and of changes in sessional data, in Tables 40 and 41.

Change scores (posttreatment - baseline) were used as the covariates in analyses of covariance to elucidate the relationship between these changes in physiological parameters and change in headache scores. No relationships emerged. Source tables are given in Appendix C, Tables 42-53.

To discover prognostic indicators, two groups - those who improved on Headache Index by more than 50% and those who improved by less than 25% - were compared on several variables, tabulated in Table 7. At post-treatment, the improved group differed significantly from the nonimproved only with respect to type of treatment (X^2=14.19, p=.003). The number of subjects improved in the waiting list group was less than in the treated groups (X^2=10.13, p=.01); 65% of the EMG feedback group, 88% of the temperature feedback group and 80% of the hypnotic induction group improved. In the waiting list group, 20% improved. There were more improved patients in the temperature than in the E M G feedback group (X^2=4.25, p=.03). At follow-up, the improved and unimproved groups did not differ significantly from each other on any tested variable.

Discussion

The hypothesis that the effectiveness of a biofeedback modality is specific only to the appropriate headache type, was not supported.

Table 7

Comparisons of Improved (>50%) and Unimproved (<25%) Groups at Posttreatment and Follow-up.

Group	Posttreatment				Follow-up			
	Imp	Unimp	t	p	Imp	Unimp	t	p
N	38	15			29	12		
Headache type								
Migraine	19	7			15	8		
Tension	19	8			14	4		
Treatment								
E M G	13	7			9	5		
Temp	15	1			15	3		
H Y P	8	1			5	3		
W L	2	6						
Sex								
Males	8	4			6	3		
Females	30	11			23	9		
Mean scores on:								
Age	33.50	30.20	0.89		32.76	33.58	0.19	
Education(yr)	12.50	14.40	1.82		12.38	14.08	1.37	
Age of onset	17.92	20.47	1.12		18.03	17.00	0.42	
Zung	40.27	39.21	0.30		42.10	35.67	1.72	
IPAT Sten	6.71	6.80	0.15		6.65	7.25	0.85	
MPI neuroticism	23.95	23.47	0.14		22.65	25.58	0.69	
MPI extroversion	25.16	26.13	0.39		23.72	28.25	1.61	
Lab performance:								
EMG baseline	15.99	20.54	1.20		16.85	14.98	0.42	
Temp baseline	50.89	48.94	1.31		50.35[c]	50.07[d]	0.17	
Change in EMG	- 3.84[a]	-10.51[b]	1.20		- 8.29	- 3.62	0.72	
Change in temp	0.61[e]	1.44[f]	0.59		0.55[g]	0.46[h]	0.06	
for Trained Groups								
E M G N	13	7			9	5		
baseline	15.73	25.07	1.07		19.03	14.33	0.40	
change	- 7.57	-15.43	0.87		-12.50	- 5.16	0.64	
Temp N	15	1			15	3		
baseline	50.29	54.58	1.40		50.51	51.42	0.50	
change	1.35	- 2.22	0.83		1.16	- 1.19	0.89	

a, n=25; b, n=13; c, n=16; d, n=11; e, n=27; f, n=10; g, n=21; h, n=9

Substantial improvement (more than 50%) in headache, regardless of headache type, was achieved in the biofeedback groups (88% - temperature biofeedback, 65% - E M G biofeedback), comparable to that obtained in other biofeedback studies (82% - Diamond & Medina, 1978; 81% - Fahrion, 1978; 82.6% - Pearse, Walter, Sargent & Mears, 1975; 58% - Solbach & Sargent, 1977) and in relaxation studies (65% - Mitch et al., 1970; 76% and 70.4% - Mitchell & Mitchell, 1971; 72% - Warner & Lance, 1975). Furthermore, 80% of the hypnotic induction group were also substantially improved. Surprisingly, temperature biofeedback was significantly more effective than E M G biofeedback across headache types but temperature biofeedback did not differ significantly from hypnotic induction. While there was a trend for change in E M G to be related to duration of headache, no such relationship occurred between temperature change and any headache variable. Type of headache did not influence treatment outcome; as many migraine as tension headache subjects improved regardless of treatment. The treatment effect cannot therefore be attributed solely, if at all, to the biofeedback training. Several postulates can be examined: 1) contact with a therapist led to improvement ; 2) non-specific factors, such as suggestibility and expectancy, led to improvement; 3) subjects learned and applied general relaxation and/or coping skills which led to improvement.

Therapist Contact. All subjects were chronic headache sufferers who had previously sought treatment for their complaints, usually from physicians, and who had generally received medication of some type

(analgesics, relaxants, ergotamine, etc.). Contact with the former therapist had not led to substantial improvement in these subjects. Thus, it is doubtful that contact with a student psychologist, who falls considerably lower on an "esteemed therapist" hierarchy, was responsible for the improvement.

Non-specific Factors. Similarly, expectancy of improvement and suggestibility should have played a part in treatment outcome with physicians. That they did not (at least for the subjects of this study) may be due, however, to other mitigating factors. High expectancy of improvement with a drug would fall off rapidly, following an extinction curve, if the drug failed to reduce symptoms. Many headache subjects, particularly those with migraine headaches, remark on the necessity to take their ergot preparations prior to the onset of pain. Once pain sets in, no amount of medication brings relief. (This is so because the ergotamine prevents the dilatation and distention of the arteries which appears to be responsible for the headache pain). By contrast, a proposed training period of five weeks should greatly reduce the expectancy of immediate improvement and resemble a partial reinforcement schedule, thus prolonging the extinction process even if the therapy is ineffectual.

Difference in expectancy of improvement of medically treated headache patients and those treated with biofeedback might stem from the fact that medically treated subjects are wary of taking any medications. They fear addiction and/or side effects and consequently refuse the

medication or take an insufficient dose initiating the same extinction process as above. In this regard, the expectancy of these same patients of success in a non-pharmacological approach may be greater than in the usual physician-prescribed remedy. Effects of expectancy cannot therefore be completely ruled out. However, the failure of Chesney and Shelton (1976) to achieve good results, suggests that expectancy was not the sole therapeutic measure. Since the subjects in the present study are a select sample to the extent that they are, for the most part, prior treatment failures, a future course of study should concern itself with the difference between successes and failures of the traditional treatment approach to headache.

Thompson (1976) directly manipulated expectancy and found minimal and ambiguous support for a therapeutic effect. All of Thompson's groups (positive expectancy feedback, positive expectancy without feedback, neutral expectancy feedback, neutral expectancy without feedback) showed improvement over time, and intensity ratings were affected by the interaction of feedback and expectancy.

Graham (1974), on the assumption that suggestibility might influence the therapeutic effect of biofeedback treatment, matched his groups of migraine patients on suggestibility and found no differences in outcome between biofeedback plus hypnosis, biofeedback alone and hypnosis alone. Andreychuk and Skriver (1975) also found no difference between groups trained in biofeedback and self-hypnosis. However, when they separated their subjects into high and low suggestibility groups, there was a significantly greater reduction in headache rate for the high suggestibility subjects.

While suggestibility was not measured directly in the present study, the random assignment of subjects to different treatment groups should have insured similar numbers of high and low suggestibility subjects in all treatment groups.

Self-observation and monitoring of a target behaviour, a component of most behaviour therapies, may constitute another non-specific factor in the present study. The direction of behaviour change induced by self-recording is often in a therapeutic direction (Lipinski & Nelson, 1974; McFall, 1970; McFall & Hammond, 1971) and may be responsible for positive outcome in biofeedback treatments of headache. However, the subjects on the waiting list also self-recorded headache activity to the same extent as the other groups, yet they failed to show significant improvement in headache complaint - only two subjects reported greater than 50% improvement. Therefore, the contribution of self-recordings to treatment outcome in this study seems negligible.

Having ruled out these non-specific factors as primary agents of change yet, failing to find support for a specificity-of-feedback modality hypothesis, one must consider the non-specific, perhaps crucial, nature of relaxation training in the successful reduction of headache complaint. Several studies have selected relaxation training as an attention-placebo control condition (Blanchard et al., 1978; Melzack & Perry, 1975; Paul, 1969) or as a treatment modality for headache patients (Cox et al., 1975; Ehrisman, 1973; Haynes et al., 1975; Hutchings & Reinking, 1976). Some studies (Blanchard et al., 1978;

Perry & Melzack, Note 4) have demonstrated that headache sufferers given relaxation training derive as much benefit or almost as much benefit as those treated with biofeedback. In their recent review, Turk, Meichenbaum and Berman (1979) conclude that "for the treatment of tension and migraine headaches...biofeedback was not found to be superior to less expensive, less instrument-oriented treatments." Certainly, the hypnotic induction programme of the present study led to at least equivalent improvement in headache complaint. In terms of cost effectiveness, the hypnotic induction group did better since they improved as much as did the biofeedback groups with less therapist contact. One advantage accruing to the hypnotic induction group but not to the biofeedback group was the availability of the taped instructions for home practice. No equipment could be provided to biofeedback subjects but they were told to practice at home what they were learning in the lab.

In all studies reporting successful outcome of biofeedback (e.g. Budzynski et al., 1973; Hutchings & Reinking, 1976) or relaxation training (Tasto & Hinkle, 1973; Warner & Lance, 1975) subjects were given instructions to practice regularly. When such instructions were omitted (Chesney & Shelton, 1976), E M G biofeedback was no better than a no-treatment control in reducing headache complaints. Furthermore, over a one year follow-up period, Reinking and Hutchings (Note 8) found that those subjects who continued to practice regularly, had significantly fewer headaches than those who did not practice, regardless of initial treatment. Thus, practice of relaxation appears important to the reduction

of headache, be it tension or migraine.

What might account, in part, for the success of both biofeedback and relaxation training in the treatment of headache, is provision to the patient of a skill or coping mechanism with which he can combat headache. The state of helplessness in face of a migraine attack seems to provoke in many subjects the dread of future attacks. Knowing that he or she has the means to control the attack, reduces the patient's anticipatory fear and perhaps eliminates a contributing factor of migraine onset.

Mitchell and Mitchell's highly successful combined behavioural treatment of migraine (1971) and tension headache(Mitchell & White,1978) appears to teach the patients not only to control headache attacks but also to deal with the situations and stimuli thought to precipitate the attack. The combined treatment included desensitization, social skills training and assertiveness training as well as relaxation training. Emphasis is placed on the subject's responsibility for action in altering his responses to daily living and on his application of the skills he has developed in treatment. In this respect, the Mitchell and Mitchell treatment programme is similar to programmes for chronic pain (Bonica, 1974; Fordyce, 1976; Ramsay & Catchlove, Note 7) wherein mechanisms for coping with pain, including but not limited to headache, are a part of a total programme concerned with environmental manipulations, modification of social reinforcers and altered reinforcement for pain behaviour.

Like all chronic pain patients, the headache patients in this and other biofeedback studies have long standing complaints. And as with chronic pain patients, the headache patients have developed modes of living which serve to maintain the headache complaints. It is because

of this chronicity that a multifaceted programme is indicated. Whether a single treatment approach would be beneficial for individuals at the onset of their headache complaints, remains to be studied.

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APPENDICES

HEADACHE REPORT

Name: _____

Date/ Time	Precipitating Event if Any	Intensity of Attack Before Medication	Intensity of Attack After Medication	Duration of Attack in hours	Treatment	Results of Treatment

Intensity
(0) No Headache
(1) slight-only aware when attention directed to headache
(2) moderate-headache can be ignored at times
(3) moderately severe-painful but still able to work
(4) severe-difficult to concentrate, can do only routine tasks
(5) incapacitating

Results
(1) Recovered
(2) Much improved-intensity reduced
(3) Moderately improved-" " " by 25-50%
(4) Slightly improved- " " " 1-25%
(5) No change

Appendix B

Hypnotic Induction Instructions[1]

First of all, make yourself comfortable in the chair -- and then, look at the dot on the wall. Just begin staring at it. In the meantime, I am going to give you some simple instructions which will help you to experience hypnosis. You'll find that you can quickly learn to follow these instructions and to experience the things I describe to you. With practice on subsequent days you will find that you can experience these things with greater vividness, with greater intensity than you did at first.

As you stare at the dot on the wall, you may find that occasionally your gaze may wander. And that your vision may even blur. If this happens, simply refocus your eyes and continue staring evenly at the dot on the wall.

Now take a deep breath in, and hold it: Hold it until it starts to feel uncomfortable and then, when it starts to feel uncomfortable, just let it out very slowly. (Long pause). You find that you are starting to experience a comfortable feeling; — a feeling of well-being begins to develop as you continue to rest in the chair. Just looking at the dot on the wall, listening to my voice. Now take another deep breath in and hold it —

Notice the feeling of tightness and tension in your chest and abdomen — and then, as it starts to feel uncomfortable just as you did before, let it out very slowly. (Long pause).

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[1] adopted from Melzack and Perry, 1975.

Notice that with breathing out — with letting the tension out of your lungs — you become even more aware of a feeling of comfort and well-being settling over you.

Just sink deeper into the chair, and focus your attention closely on feelings of relaxation in various parts of your body -- in your head and your neck, in you arms and in your legs, in your chest and in your back. And just breathe freely and evenly and deeply — freely, evenly and deeply, not too quickly, not too slowly. Just at a comfortable rate for you to notice that relaxation increases gradually as you breathe out.

You may even be aware of the walls of your chest growing looser — just rest there for a moment experiencing the sensation. Continue relaxing your chest so that feelings of warmth and comfort radiate to your back and your shoulders and your neck and your arms and your legs.

You're probably starting to notice certain changes in the dot on the wall — changes that occur from staring at it for so long. Sometimes the dot on the wall looks like its moving up and down, or from left to right. Sometimes it may not look like a coloured dot on the wall, but a small hole in the wall. At other times it might seem like a coloured patch just a few inches in front of the wall. You may see some of these things or even all of these things. Whatever you see, just continue staring at the dot; continue listening to my voice. Continue to become more deeply relaxed, more deeply relaxed.

And as you watch the dot on the wall, your eyelids become heavier and heavier and your eyes are becoming tired from staring. Your eyelids start to feel very tired and heavy, as you sit there breathing freely and evenly and deeply — breahing in, breathing out freely, evenly, deeply. The eyelids are becoming so heavy, so tired that soon they will just close of their own accord, as if they were coated with a lead paste; as if there were magnetic fields in the eyelashes drawing the eyelashes together.

Concentrate now, even more closely on feelings of relaxation and comfort in various parts of your body. First of all, think of relaxation in the muscles of your left arm — the hand, the fingers of the left hand ... the left forearm... the left upper arm ... the left shoulder. Think of relaxation in each of these areas and as you think of the relaxation, the muscles become progressively more relaxed.

Then ... relax the muscles of your neck ... your chest ... your back. Relax each of these muscle groups ... the neck ... the chest ... the back. And as you relax these muscles, your facial muscles will also relax and loosen of their own accord. Then relax the stomach muscles by doing this: ... tighten your stomach muscles ... make your abdomen hard ... and then, let the tension out ... notice the feeling of well-being that comes with relaxing your stomach ... like a gentle massaging action all over your stomach and even up to your chest.

Then relax the muscles of your legs ... the right leg ... the right foot ..., try to feel it in the toes of your right foot ... and then the right calf ... the right thigh.

Just thinking about relaxation in these areas causes the muscles to become more relaxed and you may even feel an interesting thing happens. That the feelings of relaxation you feel in each of these areas of the body start to spread and irradiate so that they may seem to join up like the parts of a jigsaw puzzle and you feel a deep feeling of overall relaxation. Of contentment and of well-being permeating the whole of your body.

And your eyes will probably have closed now from concentrating so carefully on the dot on the wall, but, if they haven't, just close them gently now of your own accord and take a deep breath in and hold it and then, when it starts to feel uncomfortable just as you've done before ... just let it out slowly.

With your eyes closed, you are ready to experience hypnosis - to experience it more profoundly - but you will find an interesting thing is happening. That no matter how deeply relaxed you ever feel, no matter how deeply in hypnosis you ever feel, your mind is always clear. You're always aware of my voice and of what I am saying to you. You are completely aware of everything that is happening around you even though you are deeply relaxed -- deeply in hypnosis.

You can now go even deeper into hypnosis. Say to youself — just by thinking it — "Now I am going deeper and deeper." Think it to yourself. And imagine yourself standing at the top of an escalator. Visualize the scene of the escalator — of the steps moving down -- and picture the moving hand rail.

Count backwards slowly from ten to zero, imagining, as you count that you are stepping onto the first step of the escalator and standing with your hands on the railing while the steps move down carrying you deeper and deeper into hypnosis. You can plan it so that you reach zero just as you reach the bottom and step off the escalator. It will take you about 1 minute.

(Pause 60 seconds)

You have now become so deeply relaxed — so deeply in hypnosis — that your mind has become so sensitive — so receptive to what I say — that everything I say to you — will sink so deeply into the furthermost recesses of your mind — and will make so deep and lasting an impression there.

And because these things will remain — firmly embedded in the deepest parts of your mind — after you have left here — when you are no longer in this room — they will continue to exercise the same profound impression — just as strongly — just as surely — just as powerfully — when you are back at home — or anywhere else you happen to be — as when you are actually here in this room, listening to my voice.

As a result of this deep relaxation — this deep hypnosis — you are going to feel physically stronger and fitter and healthier in every way. You will feel more alert — more wide awake — more energetic. You will become much less easily tired — much less easily fatigued — much less easily discouraged.

Every day you will become so deeply interested in whatever you are doing -- in whatever is going on around you -- that your mind will become completely distracted away from everything else -- you will no longer think nearly so much about yourself -- you will become much less conscious of yourself -- much less concerned with yourself and with your own feelings.

Every day your nerves will become stronger and steadier -- your mind calmer and clearer -- more composed -- more placid -- more tranquil. You will find that it takes a lot for things to worry you -- that it takes a lot for things to upset you even slightly.

You'll be able to think more clearly -- you'll be able to concentrate more easily -- you'll be able to give up your whole undivided attention to whatever you are doing -- to the complete exclusion of everything else. As a result you will find it easier to remember things than you do now -- you will be able to see things in their true perspective -- without magnifying them -- without ever allowing them to get out of proportion.

Every day you will become and you will remain emotionally more calm -- much more settled -- much less easily disturbed. Every day you will become -- and you will remain -- more and more completely relaxed -- much less tense each day -- both mentally and physically -- wherever you are -- at home -- or anywhere else you happen to be.

And as you become -- and as you remain -- more relaxed and less tense each day -- so -- you will develop much more confidence in yourself.

More confidance in your ability to do -- not only what you have to do each day -- but more confidence in your ability to do whatever you ought to do -- without feeling that you might fail -- without feeling uneasy.

Because of this -- every day -- you will feel more and more independent -- more able to stand up on your own 2 feet -- more able to hold your own -- no matter how difficult or trying things may be.

Every day -- you will feel a greater feeling of personal well-being -- a greater feeling of personal serenity -- than you have felt for a long, long time.

And because all these things will begin to happen -- more and more rapidly -- more and more powerfully -- more and more completely -- every time you hear my voice on this tape -- every time you practice these hypnosis exercises by yourself -- you will feel much happier -- much more contented -- much more optimistic in every way.

You will, consequently, be much more able to rely upon and depend upon yourself -- your own efforts -- your own judgements -- your own opinions. You will feel -- much less need to have to rely upon -- or to depend upon -- other people.

And now just rest there enjoying the feeling of warmth and comfort and relaxation that have been developing during this hypnosis session. Think particularly about those sensations I've described to you that you find especially pleasant.

TWO MINUTES OF SILENCE

As you continue to practice these hypnosis exercises, you will find that each day you are less and less aware of your headache. The unpleasant quality of the pain will tend to fade away. You may continue to feel pressure, or warmth, or cold, ... but it will not worry you. The headache may not change right away -- sometimes it takes a little time. But every time you practice, you become better able to control the pain. -- The pain becomes a little less intense, a little more bearable -- until you find you can control your headaches whenever you wish.

When you are practicing these hypnosis exercises by yourself it is very important that you always wake yourself up at the end, rather than just going off to sleep. You will find that you get better results this way. Now, just rest there for about one minute and then, after one minute, say to yourself "Now I am going to wake up" and then count from one to three. You will wake up feeling refreshed and buoyant, as though you have been in a deep and dreamless sleep. You will have a feeling of vigor, of vitality -- vigor -- vitality.

And remember to do these exercises in your own time and to practice them regularly.

ONE MINUTE SILENCE

And now that the minute is up - say to yourself "Now I am going to wake up" and count from 1 to 3.

Table 1

Analysis of Variance for Age

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	1056.13333	1	1056.13333	9.83	0.0028
B	295.48333	3	98.49444	0.92	0.4393
AB	1335.08333	3	445.02778	4.14	0.0105
Error	5587.20000	52	107.44615		

Note: A=type of headache; B=type of treatment; T=time, for this and all subsequent tables.

Table 2

Analysis of Variance for Age of Onset Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	1.63333	1	1.63333	0.03	0.8691
B	104.48333	3	34.82778	0.59	0.6275
AB	323.15000	3	107.71667	1.81	0.1569
Error	3095.60000	52	59.53077		

Table 3

Analysis of Variance for Zung Depression Scale Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	79.29515	1	79.29515	0.69	0.4104
B	603.69894	3	201.23298	1.75	0.1690
AB	766.67487	3	255.55829	2.22	0.0972
Error	5753.00000	50	115.06000		

Table 4

Analysis of Variance for IPAT Sten Score Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	0.67500	1	0.67500	0.19	0.6665
B	3.43333	3	1.14444	0.32	0.8120
AB	40.63333	3	13.54444	3.77	0.0160
Error	186.90000	52	3.59423		

Table 5

Analysis of Variance for MPI Neuroticism Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	18.40833	1	18.40833	0.15	0.6962
B	411.43333	3	137.14444	1.15	0.3383
AB	1279.43333	3	426.47778	3.57	0.0200
Error	6208.90000	52	119.40192		

Table 6

Analysis of Variance for MPI Extroversion Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	56.03333	1	56.03333	0.85	0.3616
B	145.65000	3	48.55000	0.73	0.5364
AB	548.98333	3	182.99444	2.77	0.0509
Error	3439.40000	52	66.14231		

Table 7

Headache scores, baseline through follow-up, for all subjects:

Frequency (Mean number of headaches per week).

Group	S	Base*	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	F.U.*
M-EMG	1	0.9	0.0	0.0	1.0	0.0	2.0	0.3
	2	18.0	12.0	7.0	6.0	17.0	16.0	6.0
	3	1.0	0.0	1.0	0.0	1.0	1.0	0.3
	4	1.6	3.0	3.0	4.0	3.0	1.0	2.6
	5	1.2	1.0	1.0	2.0	1.0	0.0	1.5
	6	4.0	1.0	1.0	4.0	6.0	4.0	4.5
	7	0.5	1.0	1.0	2.0	0.0	1.0	2.0
	8	4.0	1.0	0.0	0.0	0.0	0.0	0.5
	9	7.0	3.0	2.0	4.0	1.0	0.0	2.0
	10	1.0	1.0	1.0	3.0	1.0	0.0	0.5
T-EMG	1	7.0	7.0	7.0	7.0	7.0	7.0	7.0
	2	3.0	0.0	3.0	2.0	1.0	1.0	0.7
	3	7.0	7.0	7.0	7.0	7.0	7.0	7.0
	4	7.0	7.0	3.5	3.0	1.0	3.0	0.5
	5	3.0	2.5	4.0	1.0	5.0	5.0	1.7
	6	3.5	3.0	1.0	3.0	0.0	0.0	-1
	7	7.8	1.0	0.0	0.0	2.0	0.0	1.5
	8	0.8	1.0	1.0	0.0	0.0	0.0	0.5
	9	1.0	0.0	2.0	0.0	0.0	0.0	1.0
	10	8.8	11.0	7.0	7.0	6.0	6.0	8.5

Table 7 cont'd

M-temp	1	0.5	0.0	1.0	0.0	0.0	1.0	0.2
	2	5.5	5.0	2.0	3.0	4.0	2.0	0.2
	3	0.8	5.0	0.0	2.0	1.0	3.0	1.0
	4	5.0	3.0	2.0	4.0	3.0	5.0	3.3
	5	0.5	-1	-1	-1	-1	-1	0.5
	6	0.5	-1	-1	-1	-1	-1	0.3
	7	1.3	1.0	1.0	1.0	2.0	0.0	0.1
	8	1.5	3.0	1.0	1.0	4.0	2.0	0.0
	9	5.0	3.0	1.0	0.0	0.0	2.0	1.0
	10	5.8	4.0	3.0	0.0	2.0	1.0	0.7
T-temp	1	14.4	16.0	13.0	2.0	7.0	1.0	2.0
	2	1.5	3.0	2.0	0.0	2.0	0.0	1.3
	3	0.6	1.0	0.0	0.0	0.0	0.0	0.8
	4	2.5	2.0	2.0	2.0	1.0	2.0	1.8
	5	3.0	3.0	3.0	0.0	4.0	0.0	1.5
	6	2.5	-1	-1	-1	-1	-1	2.5
	7	4.0	3.0	2.0	5.0	0.0	3.0	1.0
	8	3.0	2.0	3.0	3.0	3.0	1.0	2.0
	9	7.0	7.0	7.0	7.0	7.0	7.0	7.0
	10	3.0	2.0	2.0	2.0	2.0	2.0	3.0
HYP	1	1.8	2.0	3.0	2.0	1.0	2.0	-1
	2	2.0	1.0	0.0	2.0	2.0	1.0	1.3
	3	1.3	2.0	2.0	0.0	2.0	0.0	0.3
	4	1.0	2.0	3.0	0.0	0.0	2.0	1.3
	5	8.0	0.0	0.0	3.0	5.0	5.0	4.0

Table 7 cont'd .

HYP	6	1.8	2.0	2.0	2.0	1.0	1.0	2.2
	7	1.8	0.0	3.0	0.0	0.0	0.0	0.0
	8	1.0	0.0	1.0	2.0	2.0	0.0	0.3
	9	4.5	1.0	3.0	1.0	3.0	0.0	2.5
	10	1.4	2.0	1.0	4.0	2.0	1.0	2.0
WL	1	3.0	3.0	1.0	0.0	2.0	2.0	a
	2	7.8	8.0	9.0	10.0	9.0	12.0	
	3	0.5	1.0	2.0	0.0	0.0	1.0	
	4	7.0	7.0	7.0	7.0	7.0	7.0	
	5	7.0	7.0	7.0	7.0	-1	7.0	
	6	7.0	5.0	4.0	6.0	6.0	5.0	
	7	2.0	2.0	1.0	1.0	1.0	3.0	
	8	2.0	7.0	7.0	5.0	7.0	5.0	
	9	1.5	4.0	1.0	2.0	0.0	0.0	
	10	14.5	13.0	16.0	17.0	5.0	15.0	

* data collected over 4 week period

a offered treatment

Table 8

Headache scores, baseline through follow-up, for all subjects: Intensity (0-5 point scale, mean rating per headache per week).

Group	S	Base*	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	F.U.*
M-EMG	1	3.6	0.0	0.0	4.0	0.0	4.5	3.0
	2	2.0	2.0	2.0	2.0	2.4	2.7	2.0
	3	3.0	0.0	2.0	0.0	4.0	4.0	3.0
	4	3.2	2.3	2.3	2.3	2.7	4.0	2.5
	5	3.1	5.0	1.0	3.0	5.0	0.0	3.0
	6	1.5	3.0	2.0	2.0	1.8	1.0	2.5
	7	5.0	4.0	3.0	3.5	0.0	3.0	3.0
	8	3.3	4.0	0.0	0.0	0.0	0.0	3.0
	9	3.0	2.5	1.5	2.8	3.0	0.0	1.5
	10	4.5	2.0	1.0	2.8	2.0	0.0	1.5
T-EMG	1	4.5	4.0	3.7	4.0	4.5	4.0	3.5
	2	1.3	0.0	2.3	2.0	2.0	1.0	1.5
	3	3.0	2.5	2.8	2.8	2.0	2.5	2.0
	4	3.0	3.0	2.6	2.8	1.0	1.3	2.0
	5	4.0	2.6	3.0	3.0	2.4	2.8	3.1
	6	4.0	2.3	3.0	2.7	0.0	0.0	-1
	7	4.0	1.0	0.0	0.0	1.5	0.0	2.5
	8	3.3	3.0	3.0	0.0	0.0	0.0	3.7
	9	1.7	0.0	1.0	0.0	0.0	0.0	4.0
	10	2.3	1.9	2.2	2.2	2.3	2.2	2.2

Table 8 cont'd

M-temp	1	5.0	0.0	4.0	0.0	0.0	3.0	2.0
	2	2.0	1.4	4.0	1.5	1.0	1.5	2.0
	3	5.0	3.4	0.0	2.0	4.0	3.7	4.0
	4	2.8	2.3	2.5	2.2	2.2	2.6	3.0
	5	4.0	-1	-1	-1	-1	-1	4.0
	6	3.0	-1	-1	-1	-1	-1	3.5
	7	5.0	5.0	5.0	5.0	5.0	0.0	5.0
	8	3.0	2.0	2.0	2.0	2.5	1.0	0.0
	9	2.0	2.2	2.0	0.0	0.0	1.5	1.5
	10	2.7	1.8	2.2	0.0	1.5	1.5	3.0
T-temp	1	2.2	2.6	2.8	3.0	2.6	4.0	3.0
	2	2.0	3.0	2.5	0.0	2.0	0.0	3.0
	3	2.4	2.0	0.0	0.0	0.0	0.0	3.0
	4	2.0	4.0	1.5	1.5	1.5	2.5	2.0
	5	2.7	3.0	2.0	0.0	2.3	0.0	1.5
	6	2.0	-1	-1	-1	-1	-1	3.0
	7	2.3	2.0	1.5	2.6	0.0	2.7	2.0
	8	1.7	2.0	2.7	1.5	2.7	1.0	1.5
	9	2.0	1.5	1.0	1.0	1.0	1.0	1.0
	10	3.2	3.0	2.0	2.0	2.0	2.0	2.0
HYP	1	3.6	3.0	3.3	2.0	1.0	3.0	-1
	2	2.0	3.0	0.0	1.0	1.0	1.0	1.0
	3	1.9	2.5	2.0	0.0	2.0	0.0	2.0
	4	2.0	2.0	2.0	0.0	0.0	3.0	2.0
	5	2.3	0.0	0.0	2.0	2.0	1.5	2.6

Table 8 cont'd

HYP	6	2.3	2.5	2.0	1.5	2.0	2.0	2.4
	7	2.7	0.0	3.0	0.0	0.0	0.0	0.0
	8	3.0	0.0	3.0	1.8	2.7	0.0	4.0
	9	3.6	3.0	3.7	1.0	3.3	0.0	3.0
	10	3.1	2.0	2.0	2.5	2.0	2.0	2.0
WL	1	1.8	1.8	2.0	0.0	1.5	2.3	a
	2	2.4	3.0	2.7	2.0	2.5	2.5	
	3	3.0	3.0	4.0	0.0	0.0	3.0	
	4	3.5	3.6	3.6	4.0	3.3	3.4	
	5	2.4	1.9	1.9	1.3	-1	2.7	
	6	2.0	2.4	2.8	1.5	1.7	1.4	
	7	2.4	2.0	2.0	2.0	1.5	3.0	
	8	4.0	1.8	2.1	3.9	2.4	2.2	
	9	3.0	2.3	5.0	2.0	0.0	0.0	
	10	4.1	3.7	4.3	4.2	4.0	4.3	

* data collected over 4 week period

a subjects offered treatment.

Table 9

Headache scores, baseline through follow-up, for all subjects: Duration (Mean length of headache per week).

Group	S	Base*	Wk 1	Wk2	Wk 3	Wk 4	Wk 5	F.U.*
M-EMG	1	19.3	0.0	0.0	18.0	0.0	60.0	18.0
	2	3.0	2.5	4.0	4.0	3.5	2.1	10.0
	3	4.5	0.0	1.8	0.0	4.0	26.0	3.0
	4	6.2	2.7	6.8	5.0	5.3	9.0	3.3
	5	5.7	24.0	0.3	7.5	10.0	0.0	8.0
	6	3.7	3.0	1.0	4.4	3.3	2.0	9.1
	7	14.0	6.0	10.0	6.0	0.0	4.0	4.0
	8	26.5	72.0	0.0	0.0	0.0	0.0	48.6
	9	4.0	3.8	3.5	2.4	6.0	0.0	1.5
	10	48.0	24.0	24.0	24.0	24.0	0.0	1.3
T-EMG	1	7.0	12.0	10.5	8.0	10.0	6.0	6.0
	2	8.0	0.0	13.3	16.0	8.0	8.0	9.5
	3	24.0	24.0	24.0	24.0	24.0	24.0	24.0
	4	24.0	24.0	18.4	24.0	8.0	24.0	24.0
	5	24.0	12.6	16.0	36.0	10.2	20.0	16.8
	6	16.0	4.7	8.0	16.7	0.0	0.0	-1
	7	2.0	3.0	0.0	0.0	14.0	0.0	4.7
	8	13.2	24.0	24.0	0.0	0.0	0.0	45.0
	9	2.7	0.0	2.5	0.0	0.0	0.0	2.5
	10	6.8	4.1	2.9	6.6	5.3	3.8	4.5

Table 9 cont'd

M-temp	1	12.5	0.0	2.0	0.0	0.0	6.0	4.0
	2	11.5	1.1	72.5	0.8	0.6	0.5	0.5
	3	99.9	28.0	0.0	12.0	18.0	14.7	36.0
	4	5.5	3.7	7.3	7.5	8.0	4.6	6.9
	5	30.0	-1	-1	-1	-1	-1	24.0
	6	50.0	-1	-1	-1	-1	-1	36.0
	7	20.4	24.0	24.0	24.0	24.0	0.0	48.0
	8	44.5	20.7	10.0	8.0	16.0	4.0	0.0
	9	4.0	8.7	6.0	0.0	0.0	3.0	2.4
	10	11.3	10.5	7.7	0.0	4.0	4.0	2.0
T-temp	1	5.5	3.3	5.8	1.5	7.1	0.5	4.0
	2	6.8	4.0	1.8	0.0	4.0	0.0	3.0
	3	26.4	3.0	0.0	0.0	0.0	0.0	0.4
	4	15.4	10.5	4.0	3.0	3.0	4.0	6.0
	5	5.0	7.0	4.7	0.0	4.5	0.0	4.2
	6	4.5	-1	-1	-1	-1	-1	3.0
	7	2.3	0.8	0.3	2.3	0.0	0.8	2.0
	8	3.3	8.5	7.3	2.0	9.0	3.0	2.0
	9	16.5	16.0	18.0	16.0	16.0	16.0	16.0
	10	3.3	2.0	2.5	2.0	2.0	2.0	1.8
HYP	1	2.5	2.0	6.0	2.0	2.0	2.0	-1
	2	5.8	27.0	0.0	7.5	4.0	2.0	3.0
	3	6.2	5.0	2.5	0.0	7.5	0.0	4.0
	4	4.0	2.0	2.5	0.0	0.0	3.0	2.8
	5	6.3	0.0	0.0	5.0	4.0	3.0	7.3

Table 9 cont'd

HYP	6	2.0	3.0	1.3	0.5	0.5	1.0	3.0
	7	10.1	0.0	15.0	0.0	0.0	0.0	0.0
	8	4.0	0.0	9.3	5.8	6.0	0.0	1.0
	9	4.3	3.0	7.3	5.0	18.0	0.0	7.6
	10	4.6	0.5	0.5	6.4	0.5	1.0	1.0
WL	1	3.0	6.0	5.0	0.0	8.5	5.0	a
	2	9.4	8.0	5.7	5.2	4.8	4.2	
	3	10.0	10.0	5.5	0.0	0.0	24.0	
	4	11.7	16.0	16.0	16.0	16.0	16.0	
	5	18.0	16.0	16.0	18.0	-1	16.0	
	6	11.7	13.6	11.9	3.6	8.7	4.6	
	7	1.6	8.5	4.0	0.5	1.5	2.8	
	8	30.0	10.2	7.8	7.2	5.4	16.2	
	9	1.5	0.9	12.5	0.5	0.0	0.0	
	10	3.9	2.4	3.1	3.4	5.1	4.5	

* data collected over 4 week period

a subjects offered treatment

Table 10

Headache scores, baseline through follow-up, for all subjects: Medication (Mean number of pills per headache per week).

Group	S	Base*	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	F.U.*
M-EMG	1	1.9	0.0	0.0	2.0	0.0	2.0	2.0
	2	3.0	3.4	2.0	2.7	2.9	2.0	2.0
	3	4.0	0.0	0.0	0.0	0.0	9.0	0.0
	4	0.5	0.7	0.5	0.9	1.0	2.0	0.4
	5	3.1	6.0	0,0	10.0	4.0	0.0	0.0
	6	1.5	1.0	1.0	4.0	4.0	1.0	0.6
	7	4.0	2.0	2.0	4.0	0.0	2.0	2.0
	8	1.5	3.0	0.0	0.0	0.0	0.0	2.3
	9	2.0	1.8	0.5	0.0	0.0	0.0	0.0
	10	6.0	4.0	2.0	5.0	4.0	0.0	5.0
T-EMG	1	8.0	8.0	8.0	8.0	8.0	6.0	6.0
	2	0.6	0.0	2.0	2.0	1.0	0.0	0.5
	3	13.0	13.0	13.0	13.0	13.0	13.0	10.0
	4	1.0	1.0	0.4	1.0	0.0	0.0	0.0
	5	3.0	1.6	0.8	4.0	0.0	0.4	0.8
	6	4.0	0.7	0.0	0.0	0.0	0.0	-1
	7	2.0	2.0	0.0	0.0	2.0	0.0	2.0
	8	2.2	4.0	2.0	0.0	0.0	0.0	4.0
	9	1.0	0.0	1.0	0.0	0.0	0.0	2.0
	10	0.8	1.0	1.0	1.3	1.3	0.8	1.6

Table 10 cont'd

M-temp	1	2.0	0.0	1.0	0.0	0.0	0.0	0.0
	2	1.0	1.0	8.0	3.0	0.3	0.5	0.0
	3	0.0	2.2	0.0	1.0	1.0	0.7	6.0
	4	1.6	0.7	1.5	1.3	2.0	0.8	1.8
	5	2.0	-1	-1	-1	-1	-1	2.0
	6	4.8	-1	-1	-1	-1	-1	4.0
	7	9.2	10.0	10.0	10.0	10.0	0.0	16.0
	8	3.0	3.0	2.0	2.0	3.0	0.0	0.0
	9	2.0	1.0	1.0	0.0	0.0	1.5	0.0
	10	1.7	2.0	3.0	0.0	2.0	2.0	1.0
T-temp	1	0.1	0.1	0.1	0.0	0.0	1.0	0.0
	2	0.5	1.0	0.5	0.0	1.0	0.0	0.5
	3	5.4	2.0	0.0	0.0	0.0	0.0	0.0
	4	2.2	3.0	1.0	1.0	0.0	1.0	1.0
	5	3.3	4.0	6.3	0.0	5.0	0.0	5.0
	6	2.0	-1	-1	-1	-1	-1	2.0
	7	0.0	0.0	0.0	0.4	0.0	1.0	0.4
	8	0.3	1.0	0.7	0.0	1.3	0.0	0.5
	9	2.9	1.3	1.0	1.0	0.0	0.0	0.5
	10	2.0	2.0	2.0	2.0	2.0	2.0	2.0
HYP	1	2.0	2.0	2.7	1.5	1.0	2.0	-1
	2	0.5	3.0	0.0	2.0	2.0	2.0	2.0
	3	2.7	2.0	2.0	0.0	3.0	0.0	1.0
	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5	2.0	0.0	0.0	1.3	1.0	1.0	1.4

Table 10 cont'd

HYP	6	1.1	0.0	0.5	0.5	1.0	0.0	0.7
	7	1.4	0.0	0.0	0.0	0.0	0.0	0.0
	8	4.0	0.0	3.0	1.5	1.5	0.0	2.0
	9	6.5	6.0	2.5	0.0	7.5	0.0	4.4
	10	3.7	2.0	2.0	2.3	2.0	3.0	2.0
WL	1	2.0	2.7	2.0	0.0	4.0	2.0	a
	2	0.8	1.4	0.3	0.3	1.1	0.7	
	3	2.0	1.0	1.5	0.0	0.0	4.0	
	4	0.0	0.0	0.0	0.0	0.0	0.0	
	5	2.5	2.4	2.4	1.3	-1	2.9	
	6	1.5	1.4	2.0	1.0	0.5	0.2	
	7	1.0	3.0	0.0	0.0	0.0	2.0	
	8	3.0	2.0	1.6	0.4	1.1	1.7	
	9	4.5	4.3	8.0	3.0	0.0	0.0	
	10	2.0	1.8	2.0	1.6	1.8	1.7	

* data collected over a 4 week period

a subjects offered treatment

Table 11

Headache scores, baseline through follow-up, for all subjects:

Headache Index (mean per week)

Group	S	Base*	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	F.U.*
M-EMG	1	62.5	0.0	0.0	72.0	0.0	540.0	13.5
	2	108.0	60.0	56.0	48.0	142.8	90.7	120.0
	3	13.5	0.0	3.6	0.0	16.0	10.4	2.7
	4	31.7	18.6	46.9	46.0	42.9	36.0	25.5
	5	21.2	120.0	0.3	45.0	50.0	0.0	36.0
	6	22.2	9.0	2.0	35.2	25.6	8.0	102.4
	7	35.0	24.0	30.0	42.0	0.0	12.0	40.0
	8	349.8	288.0	0.0	0.0	0.0	0.0	72.9
	9	84.0	28.5	10.5	26.9	18.0	0.0	4.5
	10	216.0	48.0	24.0	201.6	48.0	0.0	16.0
T-EMG	1	220.5	336.0	272.0	224.0	315.0	168.0	147.0
	2	31.2	0.0	91.8	64.0	16.0	8.0	10.0
	3	504.0	420.0	470.4	470.4	336.0	420.0	336.0
	4	504.0	504.0	167.4	201.6	8.0	93.6	24.0
	5	288.0	81.9	192.0	108.0	122.4	280.0	88.5
	6	224.0	32.4	24.0	135.3	0.0	0.0	-1
	7	62.4	3.0	0.0	0.0	42.0	0.0	17.6
	8	34.9	72.0	72.0	0.0	0.0	0.0	83.3
	9	4.6	0.0	5.0	0.0	0.0	0.0	10.0
	10	137.6	85.7	44.7	101.6	73.1	50.2	84.2

Table 11 cont'd

M-temp	1	31.3	0.0	8.0	0.0	0.0	18.0	1.6
	2	126.5	7.7	580.0	3.6	2.4	1.5	0.2
	3	399.6	476.0	0.0	48.0	72.0	163.2	144.0
	4	77.0	25.5	36.5	66.0	52.8	59.8	68.3
	5	60.0	-1	-1	-1	-1	-1	0.6
	6	75.0	288.0	0.0	0.0	144.0	0.0	37.8
	7	132.6	120.0	120.0	120.0	240.0	0.0	24.0
	8	200.3	124.2	20.0	16.0	160.0	8.0	0.0
	9	40.0	60.0	12.0	0.0	0.0	9.0	3.6
	10	177.0	75.6	50.8	0.0	12.0	6.0	4.2
T-temp	1	174.3	137.3	211.1	9.0	295.4	2.0	24.0
	2	20.4	36.0	9.0	0.0	16.0	0.0	11.7
	3	38.0	6.0	0.0	0.0	0.0	0.0	1.0
	4	77.0	84.0	12.0	9.0	4.5	20.0	21.6
	5	40.5	63.0	28.2	0.0	41.4	0.0	9.5
	6	22.5	-1	-1	-1	-1	-1	22.5
	7	21.2	4.8	0.9	29.9	0.0	6.5	4.0
	8	16.8	34.0	59.1	9.0	72.9	3.0	6.0
	9	231.0	168.0	126.0	112.0	112.0	112.0	112.0
	10	31.7	12.0	10.0	8.0	8.0	8.0	10.8
HYP	1	16.2	12.0	59.4	8.0	2.0	12.0	-1
	2	23.2	81.0	0.0	15.0	8.0	2.0	3.9
	3	15.3	25.0	10.0	0.0	30.0	0.0	2.4
	4	8.0	8.0	15.0	0.0	0.0	18.0	7.3
	5	115.9	0.0	0.0	30.0	40.0	22.5	75.9

Table 11 cont'd

HYP	6	8.3	15.0	5.2	1.5	1.0	2.0	15.8
	7	49.1	0.0	135.0	0.0	0.0	0.0	0.0
	8	12.0	0.0	27.9	20.9	32.4	0.0	1.2
	9	69.7	9.0	81.0	5.0	178.2	0.0	57.0
	10	20.0	2.0	1.0	64.0	2.0	2.0	4.0
WL	1	16.2	32.4	10.0	0.0	25.5	23.0	a
	2	76.0	192.0	138.5	104.0	108.0	126.0	
	3	15.0	30.0	44.0	0.0	0.0	72.0	
	4	286.7	403.2	403.2	448.0	396.6	380.8	
	5	302.4	212.8	212.8	163.8	-1	302.4	
	6	163.8	163.2	133.3	32.4	88.7	32.2	
	7	6.4	34.0	8.0	1.0	2.3	25.2	
	8	24.0	128.5	114.7	140.4	90.7	178.2	
	9	6.8	8.3	62.5	2.0	0.0	0.0	
	10	231.9	115.4	213.3	242.8	306.0	290.3	

* data collected over a 4 week period

a subjects offered treatment

Table 12

Analysis of Covariance for Headache Frequency Data

(pre- to posttreatment)

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	0.20191	1	0.20191	0.01	0.9046
B	165.49030	3	55.16343	3.96	0.0134
AB	8.16084	3	2.72028	0.20	0.8989
Error	653.95718	47	13.91398		
T	8.98981	4	2.24745	0.84	0.5043
TA	7.59067	4	1.89767	0.71	0.5885
TB	28.22165	12	2.35180	0.88	0.5729
TAB	27.76489	12	2.31374	0.86	0.5874
Error	515.78222	192	2.68637		

Note: A=type of headache; B=type of treatment; T=time, for this and all subsequent tables.

Table 13

Source table for equality of slopes test in analysis of covariance of headache frequency data (pre- to posttreatment).

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	2.8510	1	2.8510	0.25	0.6184
B	186.1900	3	62.0630	5.48	0.0029
AB	11.6800	3	3.8933	0.34	0.7936
Subjects*	464.0800	41	11.3190	4.27	0.0000
Eq. of slopes	213.1758	7	30.4540	2.69	0.0217
Aver. slope[a]	1467.8000	1	1467.8000	129.67	0.0000
T	16.7520	4	4.1879	1.58	0.1807
TA	12.7160	4	3.1791	1.20	0.3119
TB	28.4410	12	2.3701	0.89	0.5531
TAB	27.3660	12	2.2805	0.86	0.5875
Residual	516.4200	195	2.6483		
Total	3223.3000	283			

* All subject effects are adjusted to allow for different slopes of covariate in the treatment groups.

a This test for zero average slope of regression coefficient is actually equivalent to a test for zero correlation.

Table 14

Analysis of Covariance for Headache Intensity Data
(pre- to posttreatment)

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	0.00685	1	0.00685	0.00	0.9618
B	16.19493	3	5.39831	1.82	0.1558
AB	0.68685	3	0.22895	0.08	0.9719
Error	139.15417	47	2.96073		
T	19.70699	4	4.92675	3.64	0.0070
TA	6.36935	4	1.59234	1.18	0.3228
TB	11.98573	12	0.99881	0.74	0.7135
TAB	19.99027	12	1.66586	1.23	0.2648
Error	260.01694	192	1.35425		

Table 15

Source table for equality of slopes test in analysis of covariance of headache intensity data (pre- to posttreatment).

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	0.0061	1	0.0061	0.00	0.9645
B	15.8590	3	5.2863	1.72	0.1767
AB	2.5163	3	0.8387	0.27	0.8439
Subjects*	125.6200	41	3.0639	2.29	0.0001
Eq. of slopes	15.0174	7*	2.1453	0.70	0.6715
Aver. slope[a]	30.6490	1	30.6490	10.00	0.0000
T	17.9720	4	4.4929	3.36	0.0109
TA	3.7218	4	0.9304	0.69	0.5955
TB	12.2680	12	1.0223	0.76	0.6862
TAB	20.2560	12	1.6880	1.26	0.2436
Residual	260.7100	195	1.3370		
Total	506.9300	283			

* All subject effects are adjusted to allow for different slopes of covariate in the treatment groups.

a This test for zero average slope of regression coefficient is actually equivalent to a test for zero correlation.

Table 16

Analysis of Covariance for Headache Duration Data
(pre- to posttreatment)

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	51.38563	1	51.38563	0.45	0.5072
B	840.05561	3	280.01854	2.43	0.0766
AB	276.66240	3	92.22080	0.80	0.4993
Error	5407.23262	47	115.04750		
T	370.04952	4	92.51238	1.14	0.3372
TA	90.51[illegible]	4	22.62751	0.28	0.8908
TB	633.73801	12	52.81150	0.65	0.7945
TAB	732.77300	12	61.06442	0.76	0.6959
Error	15526.51414	192	80.86726		

Table 17

Source table for equality of slopes test in analysis of covariance of headache duration data (pre- to posttreatment).

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	30.7660	1	30.7660	0.38	0.5386
B	485.2300	3	161.7400	2.02	0.1259
AB	560.6700	3	186.8900	2.33	0.0879
Subjects*	3281.0000	41	80.0240	1.00	0.4743
Eq. of slopes	1761.5600	7	251.6510	3.14	0.0094
Aver. slope[a]	2141.0000	1	2141.0000	26.75	0.0000
T	456.4600	4	114.1100	1.43	0.2254
TA	94,3320	4	23.5830	0.29	0.8806
TB	595.0600	12	49.5880	0.62	0.8226
TAB	715.5700	12	59.6310	0.74	0.7038
Residual	15562.0000	195	79.8030		
Total	27235.0000	283			

* All subject effects are adjusted to allow for different slopes of covariate in the treatment groups.

a This test for zero average slope of regression coefficient is actually equivalent to a test for zero correlation.

Table 18

Analysis of Covariance for Medication Data
(pre- to posttreatment)

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	2.58231	1	2.58231	0.15	0.7017
B	33.27535	3	11.09178	0.64	0.5943
AB	5.29992	3	1.76664	0.10	0.9587
Error	816.98220	47	17.38260		
T	20.91218	4	5.22805	2.19	0.0713
TA	6.88317	4	1.72079	0.72	0.5780
TB	42.15857	12	3.51321	1.47	0.1368
TAB	29.70379	12	2.47532	1.04	0.4154
Error	457.71200	192	2.38392		

Table 19

Source table for equality of slopes test in analysis of covariance of headache medication data (pre- to posttreatment).

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	0.8444	1	0.8444	0.09	0.7600
B	2.1922	3	0.7307	0.08	0.9695
AB	21.9020	3	7.3005	0.81	0.4918
Subjects*	366.3000	41	8.9341	3.80	0.0000
Eq. of slopes	148.7550	7	21.2500	2.38	0.0388
Aver. slope[a]	374.3900	1	374.3900	41.90	0.0000
T	123.7680	4	5.9420	2.53	0.0417
TA	5.4756	4	1.3689	0.58	0.6752
TB	43.1070	12	3.5922	1.53	0.1159
TAB	30.0850	12	2.5071	1.06	0.3892
Residual	457.7600	195	2.3475		
Total	1849.2000	283			

* All subject effects are adjusted to allow for different slopes of covariate in the treatment groups.

a This test for zero average slope of regression coefficient is actually equivalent to a test for zero correlation.

Table 20

Analysis of Covariance for Data of Headache Index
(pre - to posttreatment)

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	18296.87355	1	18296.87355	1.14	0.2913
B	106547,40916	3	35515.80305	2.21	0.0992
AB	23875.68904	3	7958.56301	0.50	0.6872
Error	754937.38294	47	16062.49751		
T	21611.06044	4	5405.51511	0.97	0.4252
TA	5439.65722	4	1359.91430	0.24	0.9130
TB	52645.19737	12	4387.09978	0.79	0.6634
TAB	33776.75815	12	2814.72985	0.51	0.9099
Error	1070148.34070	192	5573.68927		

Table 21

Source table for equality of slopes test in analysis of covariance of headache index data (pre- to posttreatment).

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	11634.0	1	11634.0	0.93	0.3404
B	105290.0	3	35098.0	2.80	0.0515
AB	5223.1	3	1741.0	0.13	0.9359
Subjects*	512840.0	41	12508.0	2.25	0.0001
Eq. of slopes	255496.0	7	36499.4	2.91	0.0142
Aver. slope [a]	994350.0	1	994350.0	79.49	0.0000
T	28995.0	4	7248.7	1.30	0.2695
TA	4791.3	4	1197.8	0.21	0.9295
TB	55418.0	12	4618.2	0.83	0.6178
TAB	35075.0	12	2922.9	0.52	0.8960
Residual	1077500.0	195	5554.0		
Total	3493400.0	283			

* All subject effects are adjusted to allow for different slopes of covariate in the treatment groups.

a This test for zero average slope of regression coefficient is actually equivalent to a test for zero correlation.

Table 22

Analysis of Covariance for Headache Frequency Data
(pre- through posttreatment to follow-up)*

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	4.47085	1	4.47085	0.37	0.5458
B	7.07421	2	3.53710	0.29	0.7470
AB	6.21472	2	3.10736	0.26	0.7737
Error	457.19242	38	12.03138		
T	18.48607	5	3.69721	1.34	0.2494
TA	6.78027	5	1.35605	0.49	0.7827
TB	29.39178	10	2.93918	1.06	0.3916
TAB	23.40714	10	2.34071	0.85	0.5833
Error	538.44002	195	2.76123		

* does not include WL group which was offered treatment at termination of waiting period.

Table 23

Source table for equality of slopes test in analysis of covariance of headache frequency data (pre-post-follow-up).

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	11.1060	1	11.1060	1.01	0.3199
B	3.3173	2	1.6586	0.15	0.8597
AB	3.8551	2	1.9275	0.17	0.8390
Subjects*	415.5300	38	10.9350	4.03	0.0000
Eq. of slopes	75.1482	5	15.0290	1.37	0.2135
Aver. slope[a]	830.1500	1	830.1500	75.91	0.0000
T	28.7990	5	5.7598	2.12	0.0638
TA	15.3380	5	3.0675	1.13	0.3445
TB	30.0400	10	3.0040	1.10	0.3571
TAB	21.7570	10	2.1757	0.80	0.6260
Residual	550.1000	203	2.7098		
Total	2076.7000	282			

* All subject effects are adjusted to allow for different slopes of covariate in the treatment groups.

a This test for zero average slope of regression coefficient is actually equivalent to a test for zero correlation.

Table 24

Analysis of Covariance for Data of Headache Intensity
(pre - through posttreatment to follow-up)

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	0.15775	1	0.15775	0.05	0.8197
B	3.69432	2	1.84716	0.62	0.5452
AB	0.16886	2	0.08443	0.03	0.9722
Error	113.86250	38	2.99638		
T	23.33221	5	4.66644	3.44	0.0053
TA	3.64196	5	0.72839	0.54	0.7480
TB	7.00746	10	0.70075	0.52	0.8771
TAB	15.58863	10	1.55886	1.15	0.3275
Error	264.42533	195	1.35603		

Table 25

Source table for equality of slopes test in analysis of covariance of headache intensity data (pre-post-follow-up).

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	0.0018	1	0.0018	0.00	0.9802
B	2.9285	2	1.4643	0.50	0.6086
AB	1.5323	2	0.7661	0.26	0.7699
Subjects*	110.6100	38	2.9107	2.16	0.0003
Eq. of slopes	10.7274	5	2.1454	0.73	0.6003
Aver. slope[a]	23.4620	1	23.4620	8.06	0.0000
T	26.0310	5	5.2061	3.87	0.0022
TA	2.3769	5	0.4753	0.35	0.8795
TB	7.6095	10	0.7609	0.56	0.8403
TAB	17.2500	10	1.7250	1.28	0.2417
Residual	272.8700	203	1.3442		
Total	485.3600	282			

* All subject effects are adjusted to allow for different slopes of covariate in the treatment groups.

a This test for zero average slope of regression coefficient is actually equivalent to a test for zero correlation.

Table 26

Analysis of Covariance for Data of Headache Duration
(pre- through posttreatment to follow-up)

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	10.59612	1	10.59612	0.06	0.8044
B	1389.23043	2	694.61521	4.08	0.0248
AB	301.23988	2	150.61994	0.88	0.4212
Error	6470.56222	38	170.27795		
T	499.05202	5	99.81040	1.08	0.3747
TA	80.48370	5	16.09674	0.17	0.9722
TB	577.68457	10	57.76846	0.62	0.7932
TAB	686.43167	10	68.63417	0.74	
Error	18082.18741	195	92.72917		

Table 27

Source table for equality of slopes test in analysis of covariance of headache duration data (pre-post-follow-up).

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	1.9978	1	1.9978	0.01	0.8995
B	769.9600	2	384.9800	3.11	0.0560
AB	541.1000	2	270.5500	2.18	0.1262
Subjects *	4702.1000	38	123.7400	1.37	0.0837
Eq. of slopes	1833.3900	5	366.6780	2.96	0.0235
Aver. slope[a]	3206.7000	1	3206.7000	25.91	0.0000
T	637.9500	5	127.5900	1.41	0.2184
TA	91.2630	5	18.2530	0.20	0.9608
TB	602.1000	10	60.2100	0.67	0.7514
TAB	710.4500	10	71.0450	0.79	0.6378
Residual	18242.0000	203	89.8600		
Total	33824.0000	282			

* All subject effects are adjusted to allow for different slopes of covariate in the treatment groups.

a This test for zero average slope of regression coefficient is actually equivalent to a test for zero correlation.

Table 28

Analysis of Covariance for Medication Data

(pre- through posttreatment to follow-up)

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	8.69727	1	8.69727	0.39	0.5375
B	44.80441	2	22.40221	1.00	0.3783
AB	11.17151	2	5.58596	0.25	0.7811
Error	853.50355	38	22.46062		
T	23.80660	5	4.76132	1.75	0.1239
TA	2.70021	5	0.54004	0.20	0.9625
TB	35.03617	10	3.50362	1.29	0.2375
TAB	23.37875	10	2.33788	0.86	0.5701
Error	529.04727	195	2.71306		

Table 29

Source table for equality of slopes test in analysis of covariance of headache medication data (pre-post-follow-up).

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	0.6628	1	0.6628	0.05	0.8208
B	0.7585	2	0.3792	0.02	0.9707
AB	22.2070	2	11.1048	0.87	0.4267
Subjects *	484.5300	38	12.7510	4.85	0.0000
Eq. of slopes	137.6770	5	27.5354	2.15	0.0791
Aver. slope[a]	495.5900	1	495.5900	38.86	0.0000
T	24.9430	5	4.9886	1.90	0.0956
TA	3.8936	5	0.7787	0.29	0.9143
TB	34.1690	10	3.4169	1.30	0.2312
TAB	23.5110	10	2.3511	0.89	0.5379
Residual	532.6900	203	2.6241		
Total	2129.7000	282			

* All subject effects are adjusted to allow for different slopes of covariate in the treatment groups.

a This test for average zero slope of regression coefficient is actually equivalent to a test for zero correlation.

Table 30

Analysis of Covariance for Data of Headache Index
(pre- through posttreatment to follow-up)

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	5186.51150	1	5186.51150	0.41	0.5260
B	26282,57093	2	13141.28547	1.04	0.3641
AB	17723.59222	2	8861,79611	0.70	0.5030
Error	481186.03326	38	12662.79035		
T	35864.93967	5	7172.98793	1.30	0.2674
TA	2907.23301	5	581.44660	0.11	0.9910
TB	47240.96566	10	4724.09657	0.85	0.5782
TAB	41460.39978	10	4146.03998	0.75	0.678
Error	1079726.28279	195	5537.05786		

Table 31

Source table for equality of slopes test in analysis of covariance of headache index data (pre-post-follow-up).

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	4061.6	1	4061.6	0.37	0.5449
B	3944.4	2	1972.2	0.18	0.8350
AB	2746.1	2	1373.0	0.12	0.8818
Subjects*	413740.0	38	10888.0	2.02	0.0010
Eq. of slopes	124440.6	5	24888.1	2.28	0.0654
Aver. slope[a]	616460.0	1	616460.0	56.61	0.0000
T	46962.0	5	9392.4	1.74	0.1263
TA	4895.4	5	979.1	0.18	0.9692
TB	51006.0	10	5100.6	0.94	0.4916
TAB	39656.0	10	3965.6	0.73	0.6901
Residual	1093900.0	203	5388.5		
Total	2712900.0	282			

* All subject effects are adjusted to allow for different slopes of covariate in the treatment groups.

a This test for zero average slope of regression coefficient is actually equivalent to a test for zero correlation.

Table 32

EMG activity scores, at baseline and follow-up, and difference scores (follow-up - baseline).

S	Group	M-EMG			T-EMG			HYP			WL		
	Time	B	F	F-B	B	F	F-B	B	F	F-B	B	F	F-B
1		33.4	7.4	-25.9	26.4	15.6	-10.8	23.2	14.1	- 9.1	25.1	9.7	-15.4
2		28.6	14.7	-13.9	9.1	6.6	- 2.6	14.5	8.7	- 5.8	14.9	9.2	- 5.8
3		8.3	3.6	- 4.7	16.8	16.2	- 0.7	24.9	7.4	-17.6	17.8	6.1	-11.7
4		50.8	3.1	-47.7	1.9	1.2	- 0.8	17.9	10.5	- 7.4	23.0	18.4	- 4.6
5		1.4	4.7	3.3	11.1	6.9	- 4.2	4.2	8.5	4.3	16.6	m	
6		16.6	2.8	-13.8	9.5	9.0	- 0.5	23.8	13.2	-10.6	21.4	11.5	- 9.9
7		18.6	12.5	- 6.1	2.5	2.2	- 0.3	14.7	31.4	16.8	13.2	19.8	6.6
8		6.7	10.1	3.4	17.8	6.4	-11.5	23.1	25.2	2.0	29.9	13.2	-16.6
9		17.9	13.5	4.4	7.1	17.3	10.1	16.9	32.0	15.2	14.1	37.6	23.6
10		80.3	7.4	-72.9	14.9	12.6	- 2.3	14.1	13.6	- 0.5	8.5	m	

m=missing data

Table 33

Mean EMG activity scores during baseline, feedback and transfer of training phases of weekly training sessions.

S	Group / Wk / Phase	M-EMG B	M-EMG F	M-EMG T	T-EMG B	T-EMG F	T-EMG T	HYP B	HYP F	HYP T
1	1	17.4	11.8	11.3	18.6	12.0	20.3	47.3	55.5	51.6
	2	7.9	6.6	8.8	25.8	18.1	18.7	50.8	51.6	50.0
	3	9.2	7.3	6.6	18.6	10.4	15.5	29.0	20.5	10.8
	4	8.5	8.6	8.5	23.1	19.6	21.7	23.1	10.0	7.5
2	1	8.6	9.6	11.4	5.3	4.6	4.4	21.3	16.7	12.4
	2	19.6	13.8	11.2	13.4	11.7	11.4	18.0	9.2	4.2
	3	11.6	9.3	10.6	12.9	8.8	8.8	13.8	12.1	5.6
	4	9.8	6.3	6.4	7.8	5.3	5.3	m		
3	1	1.2	1.4	0.7	42.6	25.4	19.0	9.4	8.2	17.7
	2	23.2	14.4	10.9	28.9	9.2	16.0	13.8	10.5	4.7
	3	12.5	9.2	8.7	21.7	5.4	9.2	9.8	7.6	6.1
	4	7.2	5.0	4.2	13.5	4.3	7.5	13.9	14.3	4.8
4	1	5.7	4.9	9.8	6.2	2.8	2.1	10.0	9.2	4.6
	2	2.5	1.9	2.3	6.2	4.3	3.4	23.5	20.6	12.7
	3	6.5	9.5	5.7	12.4	8.4	7.0	7.4	8.5	3.0
	4	3.5	3.9	6.1	4.8	2.6	2.0	10.1	9.2	6.1
5	1	2.7	2.1	1.7	8.6	8.3	6.3	m		
	2	3.9	1.7	1.1	4.5	5.0	4.1	m		
	3	3.2	1.8	1.6	2.2	2.5	1.9	m		
	4	3.6	1.3	1.0	2.4	4.5	4.3	m		

Table 33 cont'd

6	1	10.4	9.0	7.8	7.5	4.8	6.3	7.0	4.1	1.4
	2	2.9	2.3	2.3	3.0	2.4	2.2	15.7	8.6	6.0
	3	3.4	2.7	2.3	6.7	5.7	4.9	42.2	31.4	12.0
	4	3.2	3.1	2.9	7.4	5.6	7.4	m		
7	1	20.9	14.8	15.0	2.3	2.1	2.1	13.6	21.1	9.1
	2	20.6	9.8	7.2	4.9	4.9	4.0	12.5	12.1	8.8
	3	17.1	9.8	8.5	2.3	1.8	1.2	m		
	4	14.3	11.0	10.5	5.1	4.6	4.4	29.6	28.4	26.8
8	1	9.0	9.7	8.4	7.3	7.3	6.6	19.9	24.9	15.8
	2	8.0	8.4	6.7	5.7	4.0	4.6	25.9	35.6	11.1
	3	5.3	3.5	3.0	7.1	4.3	4.4	38.4	28.0	19.7
	4	7.8	7.3	7.0	10.2	7.4	8.5	36.5	40.0	27.4
9	1	8.1	7.6	7.5	5.2	5.5	5.5	49.2	44.5	34.8
	2	14.0	11.8	9.4	7.2	10.4	12.7	m		
	3	48.9	45.6	43.2	5.8	4.9	3.8	27.8	12.4	8.1
	4	23.2	23.2	23.6	8.2	6.9	8.1	17.6	14.0	6.2
10	1	11.1	10.5	8.9	11.2	9.3	6.9	39.5	39.9	28.3
	2	10.5	7.9	5.9	11.5	10.0	9.0	32.3	21.2	19.2
	3	15.7	15.2	12.3	8.1	6.4	6.2	20.5	18.0	19.3
	4	13.8	9.4	9.9	8.4	7.2	7.0	16.2	14.5	13.0

m=missing data

Table 34

Analysis of Variance for Change in EMG Activity Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	101.89779	1	101.89779	0.46	0.5038
B	606.71463	3	202.23821	0.91	0.4482
AB	1845.458119	3	615.16040	2.76	0.0574
Error	7587.76932	34	223.16969		

Table 35

Analysis of Variance for Change in EMG Activity from Baseline Phase to Feedback Phase of Sessions.

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	20.88146	1	20.88146	0.18	0.6750
B	52.21325	1	52.21325	0.45	0.5089
AB	11.32246	1	11.32246	0.10	0.7573
Error	2069.25422	18	114.95857		
T	126.13881	3	42.04627	4.39	0.0077
TA	54.78357	3	18.26119	1.91	0.1393
TB	67.75706	3	22.58569	2.36	0.0817
TAB	45.41878	3	15.13959	1.58	0.2044
Error	516.87721	54	9.57180		

Table 36

Analysis of Variance for Change in EMG Activity
from Baseline Phase to Transfer Phase of Sessions

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	3.44174	1	3.44174	0.04	0.8521
B	94.39519	1	94.39519	0.98	0.3351
AB	71.41597	1	71.41597	0.74	
Error	1731.88884	18	96.21605		
T	307.88185	3	102.62728	5.33	0.0027
TA	64.12638	3	21.37546	1.11	0.3534
TB	165.43857	3	55.14619	2.86	0.0452
TAB	65.68481	3	21.89494	1.14	0.3427
Error	1040.61674	54	19.27168		

Table 37

Differential temperature scores, at baseline and follow-up, and difference scores (follow-up - baseline).

S	Group	M-temp			T-temp			HYP			WL		
	Time	B	F	F-B	B	F	F-B	B	F	F-B	B	F	F-B
1		51.1	48.2	- 2.9	51.4	52.0	0.6	53.1	54.5	1.4	51.8	54.5	2.8
2		52.4	51.1	- 1.3	47.8	47.8	0.0	57.7	53.3	- 4.4	65.6	m	
3		53.8	50.4	- 3.4	47.7	53.5	5.7	51.8	51.8	0.0	48.8	m	
4		54.6	52.4	- 2.2	54.1	47.6	- 6.4	43.6	52.1	8.5	49.5	53.1	3.6
5		49.0	51.0	2.0	52.0	51.8	- 0.2	m			46.6	48.4	1.8
6		52.1	50.0	- 2.1	50.7	47.4	- 3.3	53.7	52.5	- 1.2	53.7	51.0	- 2.7
7		51.0	50.1	- 0.9	43.8	50.1	6.3	49.8	52.7	2.9	53.7	53.7	0.0
8		48.9	53.9	5.0	52.3	50.6	- 1.6	50.3	m		47.2	55.4	8.3
9		51.2	52.6	1.4	46.6	55.9	9.3	49.1	54.4	5.3	52.4	55.6	3.2
10		48.2	53.5	5.3	53.1	53.7	0.5	52.4	50.9	- 1.5	51.1	50.9	- 0.1

Table 38

Mean differential temperature scores during baseline, feedback and transfer of training phases of weekly sessions.

S	Wk	Group	M-temp			T-temp			HYP		
		Phase	B	F	T	B	F	T	B	F	T
1	1		45.9	47.2	48.3	46.9	50.3	51.0	m		
	2		52.2	53.3	54.0	49.2	47.1	47.0	m		
	3		44.9	46.9	50.2	49.5	50.0	50.8	m		
	4		47.6	49.2	49.4	37.4	36.7	38.4	m		
2	1		52.6	53.3	52.3	43.1	45.5	46.1	57.6	57.0	56.6
	2		55.3	56.5	55.9	44.6	49.1	48.2	54.2	54.9	55.1
	3		49.4	50.1	50.0	49.2	49.9	49.5	53.5	53.3	53.0
	4		51.9	53.0	52.2	49.5	50.7	49.4	m		
3	1		48.0	54.1	54.2	52.9	54.3	53.2	54.5	54.0	54.4
	2		50.0	53.1	52.1	50.6	54.1	53.6	52.7	53.2	53.1
	3		44.7	52.7	53.5	43.7	49.2	48.5	50.9	51.5	50.7
	4		51.3	53.7	51.7	53.0	56.0	56.4	54.0	50.3	49.6
4	1		55.1	55.9	54.9	48.7	52.1	52.4	51.4	51.6	51.5
	2		53.9	55.1	54.4	51.5	54.8	55.2	51.5	53.3	54.1
	3		54.6	59.0	60.8	50.5	53.6	53.9	53.7	54.0	54.2
	4		55.8	58.7	58.7	49.8	50.6	51.1	52.9	52.9	52.4
5	1		46.2	53.0	53.9	52.7	53.0	53.2	m		
	2		51.3	53.4	53.6	51.4	52.4	52.7	m		
	3		51.7	53.0	53.1	52.5	54.4	53.9	m		
	4		41.6	49.7	53.0	51.1	52.6	52.1	m		

Table 38 cont'd

6	1	55.1	55.9	55.3	46.5	47.5	47.9	52.8	53.8	54.2
	2	52.6	54.0	54.7	40.2	44.9	44.5	56.4	56.9	57.8
	3	50.3	52.7	52.4	47.7	50.1	49.5	50.5	50.2	49.9
	4	52.2	52.8	52.9	48.9	50.3	49.0	57.0	57.1	56.9
7	1	49.5	48.6	48.0	38.2	37.6	37.5	53.1	53.9	54.0
	2	50.7	52.9	53.8	44.6	49.8	49.6	50.2	51.1	50.8
	3	52.4	52.9	52.9	41.1	45.4	45.8	49.1	50.3	48.7
	4	51.1	52.7	53.1	40.7	47.1	47.8	52.0	51.4	50.5
8	1	51.5	52.4	55.1	53.0	51.1	52.0	m		
	2	51.4	53.6	55.4	50.8	50.9	51.2	m		
	3	47.6	52.2	53.3	50.7	53.2	52.4	m		
	4	56.3	56.5	56.1	52.6	52.1	52.2	m		
9	1	53.1	53.2	53.3	47.1	45.1	42.6	53.4	53.0	53.4
	2	52.3	53.9	53.0	48.4	45.8	45.7	m		
	3	51.8	52.2	52.3	47.7	41.4	39.5	50.1	51.2	51.0
	4	49.6	52.7	51.1	49.8	48.0	50.9	53.3	53.1	53.1
10	1	54.1	54.4	55.7	54.4	54.5	54.2	56.4	54.0	50.3
	2	50.4	52.2	52.7	53.2	54.2	54.2	54.1	54.6	54.4
	3	48.9	50.7	52.0	50.2	53.8	54.2	53.9	53.4	53.4
	4	55.2	56.1	56.0	53.1	53.4	54.1	50.0	50.9	49.7

m=missing

Table 39

Analysis of Variance for Change in Temperature Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	1.31967	1	1.31967	0.08	0.7739
B	47.30422	3	15.76807	1.00	0.4035
AB	17.69271	3	5.89757	0.37	0.7717
Error	550.83606	35	15.73817		

Table 40

Analysis of Variance for Change in Temperature from Baseline to Feedback Phase of Sessions

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	10.79941	1	10.79941	0.55	0.4689
B	51.90120	1	51.90120	2.63	0.1222
AB	5.04173	1	5.04173	0.26	0.6193
Error	355.14485	18	19.73027		
T	25.63250	3	8.54417	1.21	0.3159
TA	15.51565	3	5.17188	0.73	0.5382
TB	0.04664	3	0.01555	0.00	0.9999
TAB	3.88342	3	1.29447	0.18	0.9076
Error	382.18557	54	7.07751		

Table 41

Analysis of Variance for Change in Temperature from Baseline Phase to Transfer Phase of Sessions Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
A	14.61007	1	14.61007	0.63	0.4383
B	77.38595	1	77.38595	3.33	0.0848
AB	21.07287	1	21.07287	0.91	0.3538
Error	418.62205	18	23.25678		
T	37.14732	3	12.38244	1.13	0.3456
TA	17.34202	3	5.78067	0.53	0.6656
TB	5.72478	3	1.90826	0.17	0.9135
TAB	6.45608	3	2.15203	0.20	0.8985
Error	592.31363	54	10.96877		

Table 42

Regression Coefficients for Change
in Each Headache Variable from the Analysis of Covariance
where Change in EMG Activity was the Covariate

Variable	Reg. Coeff.	Std. Err.	T-Value
Frequency	-0.025559	0.03059	-0.83643
Intensity	0.01771	0.01290	1.37328
Duration	0.18220	0.09698	1.87879
Medication	-0.01190	0.01913	-0.62220
Headache Index	0.45842	1.45362	0.31536

Table 43

Summary data from the analysis of variance from the one-way analysis of covariance on change in EMG and change in headache frequency

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Equality of Adj. cell means	0.0002	1	0.0002	0.0000	0.9959
Zero Slope	5.6170	1	5.6170	0.6996	0.4095
Error	240.8576	30	8.0286		
Equality of Slopes	3.8658	1	3.8658	0.4730	0.4971
Error	236.9918	29	8.1721		

Table 44

Summary data from the analysis of variance from the one-way analysis of covariance on change in EMG and change in headache intensity

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Equality of Adj. cell means	0.0124	1	0.0124	0.0087	0.9264
Zero Slope	2.6908	1	2.6908	1.8859	0.1798
Error	42.8044	30	1.4268		
Equality of Slopes	0.4220	1	0.4220	0.2887	0.5951
Error	42.3824	29	1.4615		

Table 45

Summary data from the analysis of variance from the one-way analysis of covariance on change in EMG and change in headache duration

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Equality of Adj. cell means	32.9224	1	32.9224	0.4081	0.5278
Zero Slope	284.7664	1	284.7664	3.5299	0.0700
Error	2420.2095	30	80.6736		
Equality of Slopes	130.0149	1	130.0149	1.6463	0.2096
Error	2290.1946	29	78.9722		

Table 46

Summary data from the analysis of variance from the one-way analysis of covariance on change in EMG and change in amount of medication per headache.

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Equality of Adj. cell means	2.0572	1	2.0572	0.6552	0.4246
Zero Slope	1.2155	1	1.2155	0.3871	0.5385
Error	94.1889	30	3.1396		
Equality of Slopes	0.8393	1	0.8393	0.2607	0.6135
Error	93.3496	29	3.2190		

Table 47

Summary data from the analysis of variance from the one-way analysis of covariance on change in EMG and change in headache index

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Equality of Adj. cell means	25900.1250	1	25900.1250	1.4290	0.2413
Zero Slope	1802.6250	1	1802.6250	0.0995	0.7547
Error	543757.1875	30	18125.2383		
Equality of Slopes	13377.7500	1	13377.7500	0.7315	0.3994
Error	530379.4375	29	18288.9453		

Table 48

Regression Coefficients for Change
in Each Headache Variable from the Analysis of Covariance
where Change in Temperature was the Covariate

Variable	Reg. Coeff.	Std. Err.	T-Value
Frequency	-0.04319	0.11389	-0.37921
Intensity	-0.03861	0.05271	-0.73248
Duration	-0.34279	0.69394	-0.49398
Medication	-0.04504	0.14226	-0.31659
Headache Index	-1.97207	4.89965	-0.40249

Table 49

Summary data from the analysis of variance from the one-way analysis of covariance on change in temperature and change in headache frequency

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Equality of Adl cell means	0.8466	1	0.8466	0.1261	0.7249
Zero slope	0.9657	1	0.9657	0.1438	0.7070
Error	214.8950	32	6.7155		
Equality of Slopes	2.0527	1	2.0527	0.2990	0.5884
Error	212.8423	31	6.8659		

Table 50

Summary data from the analysis of variance from the one-way analysis of covariance on change in temperature and change in headache intensity

Source	Sum of Squares	Degrees of Freedom	Mean	F	Tail Probability
Equality of Adj. cell means	1.0479	1	1.0479	0.7284	0.3997
Zero Slope	0.7719	1	0.7719	0.5365	0.4692
Error	46.0366	32	1.4386		
Equality of Slopes	1.1133	1	1.1133	0.7682	0.3875
Error	44.9234	31	1.4491		

Table 51

Summary data from the analysis of variance from the one-way analysis of covariance on change in temperature and change in headache duration

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Equality of Adj. cell means	35.6680	1	35.6680	0.1431	0.7077
Zero Slope	60.8359	1	60.8359	0.2440	0.6247
Error	7977.7773	32	249.3055		
Equality of Slopes	34.9883	1	34.9883	0.1366	0.7142
Error	7942.7891	31	256.2190		

Table 52

Summary data from the analysis of variance from the one-way analysis of covariance on change in temperature and change in amount of medication per headache

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Equality of Adj. cell means	1.5095	1	1.5095	0.1441	0.7068
Zero slope	1.0503	1	1.0503	0.1002	0.7536
Error	335.2930	32	10.4779		
Equality of Slopes	3.6558	1	3.6558	0.3417	0.5631
Error	331.6372	31	10.6980		

Table 53

Summary data from the analysis of variance from the analysis of covariance on change in temperature and change in headache index

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Probability
Equality of Adj. cell means	203.0625	1	203.0625	0.0163	0.8991
Zero Slope	2013.4375	1	2013.4375	0.1620	0.6900
Error	397713.8750	32	12428.5586		
Equality of Slopes	662.8750	1	622.8750	0.0486	0.8269
Error	397091.0000	31	12809.3867		

Table 54

Pearson Correlation Coefficients of all Headache Variables

	Freq	Int	Dur	Med	Index
Freq	1.0000	0.4212	0.1404	0.1879	0.5530
	(0)	(284)	(284)	(284)	(284)
	p=*****	p=0.000	p=0.009	p=0.001	p=0.000
Int	0.4212	1.0000	0.5114	0.5053	0.5254
	(284)	(0)	(284)	(284)	(284)
	p=0.000	p=*****	p=0.000	p=0.000	p=0.000
Dur	0.1404	0.5114	1.0000	0.4875	0.7032
	(284)	(284)	(0)	(284)	(284)
	p=0.009	p=0.000	p=*****	p=0.000	p=0.000
Med	0.1879	0.5053	0.4875	1.0000	0.4822
	(284)	(284)	(284)	(0)	(284)
	p=0.001	p=0.000	p=0.000	p=*****	p=0.000
Index	0.5530	0.5254	0.7032	0.4822	1.0000
	(284)	(284)	(284)	(284)	(0)
	p=0.000	p=0.000	p=0.000	p=0.000	p=*****

Frequency, Intensity, Duration, Medication, Headache Index

(Coefficient/(Cases)/Significance)

The analysis was performed on all observations, ignoring structure.