Behavioral Headache Treatment: History, Review of the Empirical Literature, and Methodological Critique

Jeanetta C. Rains, PhD; Donald B. Penzien, PhD; Douglas C. McCrory MD, MHS; Rebecca N. Gray, DPhil

Theoretical developments and burgeoning research on stress and illness in the mid-20th century yielded the foundations necessary to conceptualize headache as a psychophysiological disorder and eventually to develop and apply contemporary behavioral headache treatments. Over the past three decades, these behavioral headache treatments (relaxation training, biofeedback, cognitive-behavioral therapy, and stress-management training) have amassed a sizeable evidence base. Meta-analytic reviews of the literature consistently have shown behavioral interventions to yield 35% to 55% improvements in migraine and tension-type headache and that these outcomes are significantly superior to control conditions. The strength of the evidence has lead many professional practice organizations to recommend use of behavioral headache treatments alongside pharmacologic treatments for primary headache. The present overview was prepared as a companion article to and intended to provide a background for the *Guidelines for Trials of Behavioral Treatments for Recurrent Headache* also published within this journal supplement. This article begins with a synopsis of key historical developments leading to our current conceptualization of migraine and tension-type headache as psychophysiological disorders amenable to behavioral intervention. The evolution of the behavioral headache literature is discussed, exemplified by publication trends in the journal *Headache*. Leading empirically-based behavioral headache interventions are described, and meta-analytic reviews examining the migraine and tension-type headache literatures are summarized, compared, and contrasted. A critique of the methodological quality of the clinical trials literature is presented, highlighting the strengths and weaknesses in relation to recruitment and selection of patients, sample size and statistical power, the use of a credible control, and the reproducibility of the study interventions in clinical practice.

Key words: behavioral, headache, biofeedback, stress management, review, methodology

Abbreviations: AHRQ Agency for Healthcare Research and Quality, AASH American Association for the Study of Headache, AHS American Headache Society, EEG electroencephalogram, EMG electromyographic, ICHD International Classification of Headache Disorders

(*Headache* 2005;45[Suppl 2]:S92-S109)

From the Center for Sleep Evaluation, Elliot Hospital, Manchester and Department of Psychiatry, Dartmouth Medical Center, Lebanon, New Hampshire (Dr. Rains); Head Pain Center, Department of Psychiatry and Human Behavior, University of Mississippi Medical Center, Jackson, Mississippi (Dr. Penzien); Center for Clinical Health Policy Research, Duke University Medical Center, Durham, North Carolina (Drs. McCrory and Gray); and Center for Health Services Research in Primary Care, Durham Veterans Affairs Medical Center Durham, North Carolina (Dr. McCrory).

Address all correspondence to Dr. Jeanetta C. Rains, Clinical Director, Center for Sleep Evaluation, Elliot Hospital, One Elliot Way, Manchester, NH 03103.

Behavioral headache treatments are rooted in the conceptualization of headache as a psychophysiological disorder (physical disorder influenced by psychosocial and environmental stressors). Such treatments target the patient's headache-related physiological responses (relaxation training, biofeedback) or behaviors, emotions, and cognitions (cognitive-behavioral therapy, stress-management). A very substantial quantity of empirical research evaluating these treatments has been produced within the past three decades that is largely an outgrowth of pioneering developments in biofeedback and psychophysiology in the 1970s—some deliberate and others serendipitous. This article

provides a brief contextual framework as well as a review and critique of the empirical evidence for the behavioral headache treatments that have now garnered widespread acceptance as conventional treatments for recurrent migraine and tension-type headache.

HEADACHE AS A PSYCHOPHYSIOLOGIC DISORDER: HISTORY AND FOUNDATION FOR BEHAVIORAL TREATMENT

Although the preponderance of the behavioral headache research has materialized in the past 30 years,[1,2] the view of headache as a psychophysiological disorder substantially predates contemporary behavioral research. This view was in fact well advanced by renowned headache specialist Dr. Harold G. Wolff and colleagues in the 1950s,[3-6] influenced by the early work on stress and illness of Dr. Walter B. Cannon[7,8] and Dr. Hans Selye.[9-11] The psychophysiologic view represented a critical departure from a purely psychogenic or psychopathologic view of headache based on psychoanalytic principles of psychosomatic medicine.[12] Psychogenic causality posited that a psychosomatic illness arose as a result of specific emotional conflicts experienced in early childhood that in turn were associated with specific organ systems and eventually produced specific physical symptoms. The psychosomatic formulation that the emergence of a psychosomatic illness was predetermined by early interpersonal conflicts was supplanted by the contemporary conception acknowledging that more generalized physiological responses to stress can contribute to a variety of psychophysiologic symptoms.

Cannon[7,8] defined key processes that later proved fundamental to the contemporary understanding of the bodily response to stress; he articulated the "homeostatic" function of the sympathetic nervous system in maintaining a physiological steady state, and he described the "fight or flight" response—the innate ability of a biological organism to mobilize in response to threat. But it is Selye who is credited with introducing and applying the concept of "stress" to biology and medicine.[9,10] In 1936, he published his earliest formulation of the stress theory.[9] Referencing animal experiments, he described the general and stereotyped reaction of an organism to diverse noxious agents, which he later termed "stressors" (cold, injury, shock, excessive exercise). The stereotyped hypothalamic-pituitary-adrenal response was characterized chronologically along three stages: alarm, resistance, and ultimately exhaustion. Selye noted, "Since the syndrome as a whole seems to represent a generalized effort of the organism to adapt itself to new conditions, it might be termed the 'general adaptation syndrome.'" (p. 32).[9] Selye concluded that stress played some role in the development of virtually every disease and that failure to cope with "stressors," which can be any stimuli, can result in "diseases of adaptation."[10]

While Selye's early work defined stressors as physical events, Wolff offered a psychosocial formulation of the nature of stress,[3] noting "man is further vulnerable because he reacts not only to the actual existence of danger but to threats and symbols of danger" and because "he is a tribal or group creature . . . he is dependent for his very existence upon the aid, support, and encouragement of other men" (p. 1059). The thesis of over two decades of Wolff's work was that to truly understand psychophysiological disorders such as headache, we must understand how psychosocial and physiological variables interact during stress to induce symptoms. Toward this end, Wolff developed innovative methods of observing psychological and physiological responses as people responded to naturalistic stressors, or with cleverly designed laboratory stressors. He also vigorously pursued efforts to integrate knowledge from the social and medical sciences that would be necessary to this understanding. The monograph *Social Science and Medicine* (co-authored with Leo Simmons) states Wolff's thesis concisely: "In our opinion, . . . it is the joint province of both social and physical (medical) scientists to work on the central linkage, namely, how specified stresses work to evoke particular [psychophysiological] protective reaction patterns" (p. 144–145).[5] Wolff's focus on psychophysiology (ie, the interaction of psychological and physiological variables in generating headaches) and his emphasis on the integration of relevant knowledge from the social and medical sciences would place him in the mainstream of behavioral medicine today.

The work of Wolff and others arguably reflected a paradigm shift in medicine from a traditional mind-body dichotomy toward an integrative biopsychosocial perspective.[13] Numerous journals emerged to record

the scientific investigation of behavioral/psychosocial processes in health and their role in the pathogenesis and treatment of disease.[14] The clinical field of behavioral medicine, within which most behavioral headache specialists now practice, emerged as an "interdisciplinary field concerned with the development and integration of behavioral and biomedical science, knowledge, and techniques relevant to the understanding of physical health and illness and the application of this knowledge and these techniques to prevention, diagnosis, treatment and rehabilitation."[15]

PSYCHOPHYSIOLOGY AND BIOFEEDBACK

Theoretical and technological advances in psychophysiology stimulated objective examination of relationships between the physiological and psychological processes, and lead to clinical applications for behavioral regulation of neural and visceral processes through operant learning and biofeedback.[16] The first demonstration of learned behavioral control over physiologic responses was published in 1961, and in the 1960s and 1970s human studies demonstrated that through operant feedback methods, voluntary control could be learned over many physiologic responses (eg, heart rate, blood pressure, skin conductance, muscle tension, skin temperature, evoked potentials, and various rhythms of the electroencephalogram [EEG]).[16]

Keefe and colleagues[17] reviewed foundations of psychophysiological studies of pain with the majority of the earliest applications pertaining to headache including an early electromyographic (EMG) study by Simons and Wolff[5] addressing mechanisms of posttraumatic headache. Interestingly, psychophysiology studies contributed to the rise[18] and fall of the notion that migraine was a vascular phenomenon and tension-type headache was a musculoskeletal phenomenon.[19]

The first published demonstration of biofeedback for tension headache treatment was conducted by Budzynski and colleagues who developed the EMG biofeedback model and protocol for tension headache,[20] and went on to demonstrate initial headache improvements in uncontrolled[21] and controlled[22] experiments. Around the same time, Elmer Green serendipitously discovered the application of thermal biofeedback for migraine; a migraineur undergoing thermal biofeedback for Raynaud's Disease at the Menninger Clinic reported that she was able to abort a headache at the time she was attempting to increase blood flow to her hand and raise finger temperature—this lead to the "hot hand" therapy for migraine.[23]

In the decade that followed, these initial demonstrations of the potential usefulness of biofeedback as viable form of headache therapy, in turn, stimulated publication of a host of small trials examining the role of psychological and behavioral factors in precipitating headache, further illustrating the value of a variety of "nonpharmacological" or "behavioral" headache treatments, and began examining their mechanisms of action (representative early papers include[24-36]). As addressed in detail below, the subsequent two decades have yielded increasingly more sophisticated empirical research addressing the role and value of behavioral interventions for headache.

BEHAVIORAL HEADACHE TREATMENTS

It was the fundamental shift in our conception of headache (and other "psychosomatic disorders") from psychogenic disorder to psychophysiological (or "stress-related") disorder, which paved the way for application of behavioral treatments to primary headache conditions irrespective of psychopathology. In most instances, behavioral interventions include strategies for: (i) identification and modification of behavioral headache triggers, and (ii) acquisition and use of physiological self-regulation skills aimed at *prevention* of headache episodes as opposed to aborting an acute headache. Standard behavioral interventions can be broadly categorized as: relaxation training, biofeedback training, cognitive-behavioral therapy (ie, stress-management training), or some combination or varied format of the above approaches. Most research has been carried out with adults but a literature addressing special populations (ie, pediatric, elderly) is emerging.

Relaxation Training.—Relaxation skills are presumed to decrease headache by enabling headache sufferers to modify their own headache-related physiological responses and decrease sympathetic arousal. Three types of relaxation training have been commonly employed for treatment for headache:

progressive muscle relaxation[37-40]; autogenic training involving self instructions (such as warmth and heaviness) to promote a state of deep relaxation[41]; and meditative or passive relaxation.[42,43] A relaxation-training protocol may consist of 10 or more treatment sessions, over time abbreviating and integrating the relaxation skills into everyday responses until relaxation is achieved through simple recall and eventually becoming an automated response. Protocols include instructions and materials for home practice. Relaxation techniques are often used in combination with biofeedback and stress-management.

Autogenic training, as a form of relaxation training for headache, has foundations in hypnosis.[41] Hypnosis itself has also been applied to the treatment for headache, as noted in several exemplary studies.[44-46] In its classic formulation, hypnosis is thought to induce a state of highly focused concentration combined with suspended peripheral awareness (ie, hypnotic trance), which presumably increases the patient's receptiveness to suggestion such as pain control.[47,48] Hypnosis also has been used to induce relaxation. Clearly, professional opinions differ dramatically regarding the nature and mechanisms of hypnosis. Hypnosis has been utilized as a headache intervention in Europe more broadly than in the United States. Whereas some previous reviews of the behavioral headache treatment literature have categorized hypnosis separately, other reviews have categorized hypnosis with relaxation training; the latter approach was adopted in the present review.

Biofeedback Training.—Biofeedback involves technologies to monitor physiological processes that are usually considered involuntary or that are modulated outside of conscious awareness (eg, muscle tension, pulse, blood pressure, peripheral blood flow). Information about the physiological process is converted and amplified into a signal (visual or auditory) and then fed back to the individual. With biological feedback or *biofeedback*, patients are able to learn enhanced control over the physiological process [operant learning model]. The two most common forms of biofeedback for headache have been thermal biofeedback or "handwarming" for migraine and EMG biofeedback for tension-type headache. Other types of biofeedback training (eg, alpha encephalographic, cephalic vasomotor, electrodermal) have been studied less frequently and they seldom are applied clinically.

Early on, the specific dedicated applications of thermal versus EMG biofeedback corresponded to vascular versus muscular pathophysiologies of migraine and tension-type headache presumed in the 1960s and 1970s; these preconceptions regarding headache pathophysiology have been generally discredited (in part by biofeedback research itself), and as discussed elsewhere[19] the efficacy of biofeedback is now understood to involve more complex therapeutic processes than simple physiologic retraining.[29] Biofeedback training often is facilitated by instructing patients in relaxation or autogenic exercises. Biofeedback training for headache may require a dozen or more treatment sessions with patients typically instructed to engage in daily home practice during treatment. Reliance upon the biofeedback device is gradually eliminated as the patient's self-regulation skills are consolidated.

Cognitive-Behavioral Therapy.—Cognitive-behavioral therapy and stress-management training are described extensively elsewhere[49-51] and essentially involve combining two psychological treatment approaches—cognitive therapy and behavior therapy. When used in combination, cognitive-behavioral treatments modify overt behavior by altering thoughts, interpretations of events, assumptions, and usual behavioral patterns of responding to events or stressors. Applied to headache,[52-54] these interventions alert patients to the role of thought processes in stress responses and the relationships between stress, coping, and headaches. Patients are assisted in identifying the specific psychological or behavioral factors that trigger or aggravate their headaches, and taught to employ more effective strategies for coping with headache-related stress. Often, treatment is administered in conjunction with relaxation or biofeedback training for headache, and requires from three to a dozen or more treatment sessions.

Alternate Formats for Behavioral Treatment.—Behavioral treatments usually have been administered to patients by professionals in face-to-face weekly clinic sessions, but more recently alternate formats have been developed. In the 1980s, researchers became increasingly aware of drawbacks to intensive clinic based and individually administered (or 1:1 behavioral

treatment delivery models) and began to consider issues of cost and efficiency. Minimal therapist-contact treatments have been the most extensively examined in this arena.[55-57] Minimal-contact or "home-based" formats provide similar treatment components to their clinic-based counterparts. However, skills are introduced in the clinic, but training occurs primarily at home guided by written materials and audiotapes. Consequently, only three or four clinic sessions may be necessary when behavioral techniques are delivered via this format versus the eight or more weekly clinic sessions required for the standard clinic-based format. Group, Internet, and other novel administrations of behavioral treatments have been examined to some extent and are discussed elsewhere.[2]

THE BEHAVIORAL HEADACHE TREATMENT LITERATURE

The preponderance of empirical research evaluating these treatments has been produced within the past three decades[1,2] stimulated by the birth of behavioral medicine and developments in psychophysiology as noted above. With the overwhelming majority of published clinical trials yielding positive outcomes, the evidence has led many professional practice organizations to recommend use of behavioral headache treatments alongside pharmacologic treatments for primary headache (see Table 1).

Interestingly, the American Headache Society's (AHS) recognition of biofeedback as a valid form of headache therapy in 1978[58] endures as one of the earliest formal endorsements of behavioral treatments by a medical organization, and it was forwarded while "behavioral medicine" as a discipline was in its infancy (p. 250).[15] Also among the endorsements of behavioral therapy for headache is an important evidence-based treatment guideline produced by the *U.S. Headache Consortium*, a multidisciplinary assemblage of seven professional practice organizations.[59,60] Focused upon management of migraine by the primary care practitioner, the guideline is available online in its entirety (http://www.aan.com/). The Consortium's recommendations pertaining to behavioral interventions for migraine are: (i) relaxation training, thermal biofeedback combined with relaxation training, EMG biofeedback, and cognitive-behavioral therapy may be considered as treatment options for prevention of migraine (grade A evidence), and (ii) behavioral therapy may be combined with preventive drug therapy to achieve added clinical improvement for migraine (grade B evidence).[61]

Table 1.—Professional Organizations Formally Endorsing Behavioral Interventions for Recurrent Headache

American Academy of Family Physicians[60,61]
American Academy of Neurology[60,61]
American Headache Society [58,60,61]
American College of Emergency Physicians[60,61]
American College of Physicians[60,61,116]
American Osteopathic Association[60,61]
American Medical Association[117]
Association for Advancement of Behavior Therapy[118]
Association for Applied Psychophysiology and Biofeedback[119]
Canadian Headache Society[120,121]
National Institutes of Health[122,123]
National Headache Foundation[60,61]
World Health Organization[124]

GROWTH IN BEHAVIORAL HEADACHE RESEARCH

For purposes of this review, trends were examined in the evolution of behavioral and psychological headache literature. While many behavioral headache studies were published in a broad variety of journals (medicine, behavioral medicine, clinical psychology, pain), the subsample of studies published in *Headache* nevertheless exemplifies the major trends in the quantity and type of publications reporting behavioral headache research. In order to appraise these trends, each issue of *Headache* from its inception in 1962 through 2004 was examined. The review identified and categorized 383 papers (excluding conference abstracts) that specifically addressed behavioral, psychiatric, and other psychological topics as at least part of the article's principal focus. The behavioral and psychological literature published in *Headache* has grown sharply since the 1960s (Fig. 1).

A precipitous increase in the number of publications was noted in the late 1970s with a more gradual but continuing linear ascent in subsequent decades. Prior to 1970, only nonempirical papers and clinical commentary pertaining to psychological factors had been published in *Headache*. The surge in research

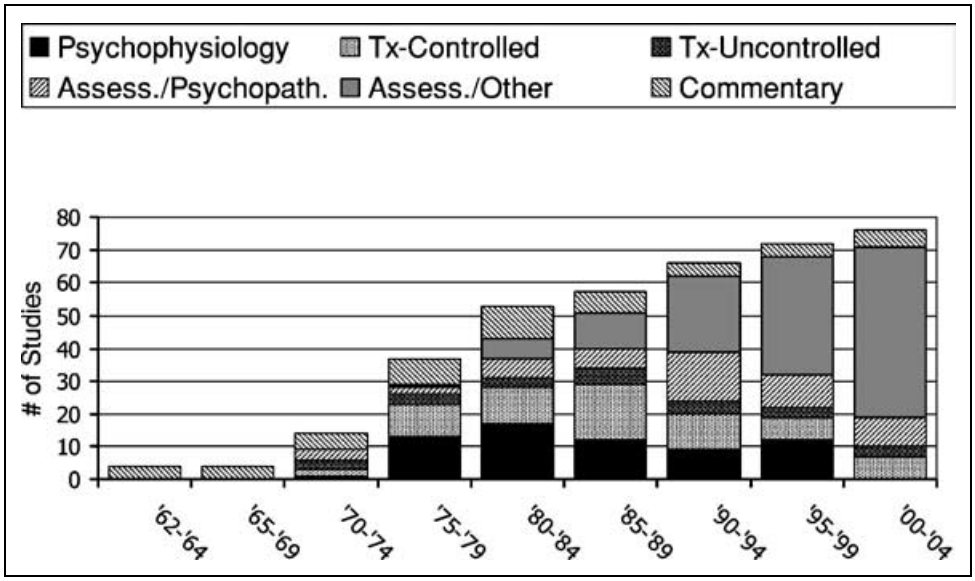

Fig 1.—Number and type of study or report of behavioral/psychiatric/psychological papers published in *Headache*. Number and type of report by 5-year period for papers addressing behavioral, psychiatric, and other psychological topics published in the journal *Headache* between 1962 and 2004. A total of 383 papers [excluding conference abstracts] categorized and graphed by type: Psychophysiology; Tx-Controlled: treatment study controlled; Tx-Uncontrolled: treatment study uncontrolled; Assess./Psychopath. report includes assessment data pertaining to psychiatric disorders or psychopathology; Assess./Other: report includes assessment data pertaining to nonpsychiatric psychological factors (eg, stress, quality of life, disability); Commentary: nonempirical clinical commentary or expert opinion pertaining to behavioral, psychiatric disorders, psychopathology, or other psychological factors.

in the 1970s was accounted for by increased psychophysiology research and controlled clinical trials. Psychophysiology research peaked in the early 1980s and has subsequently declined. With respect to clinical trials research, the number of controlled trials has increased while the number of uncontrolled trials has remained steady at a relatively small rate. The number of studies examining nonpsychiatric psychological variables has increased greatly in recent years. This burgeoning trend is largely (but not exclusively) accounted for by an increasing number of studies designed to examine headache-related disability and quality of life. Over the years there has been a fairly small but steady stream of papers providing clinical commentary or editorial of psychiatric and behavioral issues.

EMPIRICAL REVIEWS OF THE CLINICAL TRIALS LITERATURE

Meta-analytic reviews provide a quantitative, and in some cases qualitative, assessment of the sum of the behavioral headache literature and permit comparisons to parallel literatures assessing standard pharmacologic headache treatments. Meta-analysis has been used extensively in recent years in evidence-based medicine and clinical guidelines. Several meta-analytic reviews of the behavioral literature have been published using varying study inclusion/exclusion criteria. The majority of the reviews have adopted the strategy of including data from all available treatment studies regardless of experimental design (eg, single group outcome study vs controlled trial) or publication status (ie, published vs unpublished). However, the most recent meta-analyses have included only the most carefully designed and reported trials and thus selectively included only trials that were randomized and controlled. Clearly, each of these analytic strategies has its merits. The sections that follow describe the most comprehensive empirical reviews of both types, permitting comparison of the findings across different review methodologies. Meta-analyses are described for the migraine, tension-type headache, minimal-contact format, and pediatric literatures.

Migraine.—Goslin and colleagues[62] with support from the Agency for Healthcare Research and Quality (AHRQ) published the most recent meta-analysis

of the behavioral literature which also has employed the most conservative study inclusion criteria to date. The literature search identified 355 articles describing behavioral and physical treatments for migraine, of which 70 reported controlled clinical trials of behavioral treatments for migraine in adults. A total of 39 prospective and randomized trials met all of the stringent research design and data extraction requirements; the 39 trials yielded 60 treatment groups of behavioral treatments: relaxation training, temperature biofeedback, temperature biofeedback plus relaxation, EMG biofeedback, cognitive-behavioral therapy (stress-management training), cognitive-behavioral therapy plus temperature biofeedback, waitlist control, and other controls. Treatment outcome data were calculated using two metrics: summary effect size estimates and mean percentage headache improvement from pre- to posttreatment. Behavioral interventions yielded 32% to 49% reductions in migraine versus 5% reduction for no-treatment controls (Fig. 2). Results indicated that relaxation training, thermal biofeedback combined with relaxation, EMG biofeedback, and cognitive-behavioral therapy were all statistically more effective than waitlist control.

The AHRQ-sponsored meta-analysis[62] is the only empirical review of the behavioral migraine literature to date to employ highly selective study inclusion criteria. Earlier meta-analyses were maximally inclusive of the available research.[63-66] Nevertheless, the findings of the other meta-analyses closely parallel the AHRQ review indicating that behavioral treatments for migraine headache are effective (35% to 55% improvement), and all treatments are more effective than control conditions (Fig. 2). There is a sizeable amount of evidence indicating that, at least among those patients who respond initially, the effects of behavioral treatments endure over time with the longest follow-up occurring 7 years posttreatment.[66,67] For example, Blanchard and colleagues[68] found that 91% of migraine headache sufferers remained significantly improved 5 years after completing behavioral headache treatment.

The comparative efficacy of pharmacologic versus behavioral therapies for migraine has only rarely been directly assessed.[32,69-72] However, meta-analytic comparisons have yielded similar levels of improvement in migraine with propranolol (among the most widely employed and most effective preventive

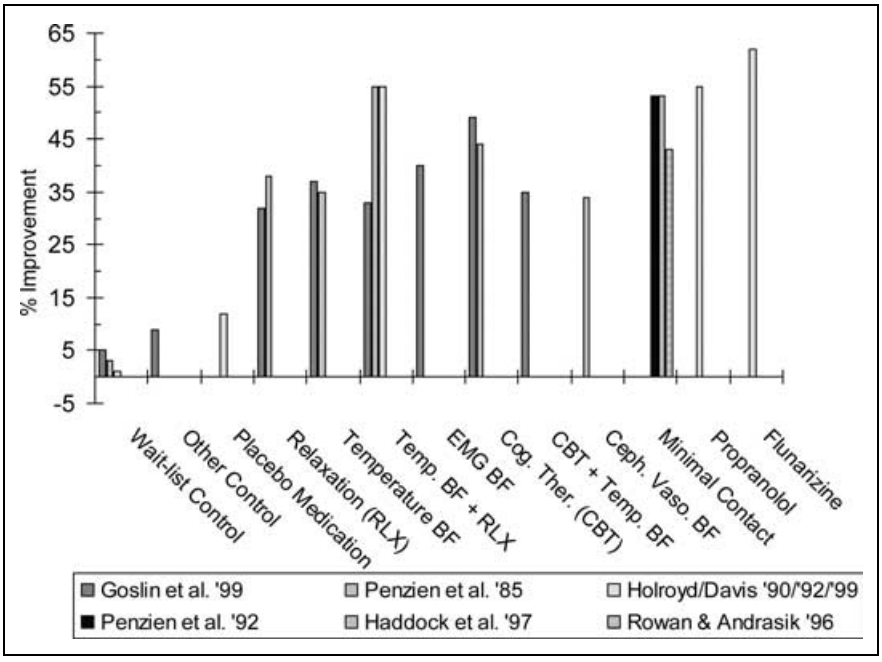

Fig 2.—Meta-analyses of behavioral and pharmacological treatments for migraine: percentage improvement scores by treatment condition. RLX: relaxation training; BF: biofeedback; EMG: electromyographic; CBT: cognitive-behavioral treatment; Ceph. Vaso. BF: cephalic vasomotor biofeedback.

pharmacologic therapies for migraine; 32 trials), flunarizine (a calcium channel blocker widely used for migraine prophylaxis in Canada and Europe; 31 trials), and combined relaxation and biofeedback training (35 trials).[65,73,74] By comparison, patients receiving placebo pills for migraine showed only a 12% improvement on average (Fig. 2). Thus, the best of the preventive pharmacologic and behavioral therapies appear to be similarly viable for uncomplicated migraine patients.

Tension-Type Headache.—A meta-analysis of behavioral treatments for tension-type headache was recently completed[75] employing methodology that closely paralleled the Goslin et al[62] review of the migraine literature. Like the Goslin and colleagues' review, this analysis employed stringent research design and data extraction requirements and selectively included only randomized, controlled trials. McCrory and colleagues'[75] literature search identified 107 articles describing behavioral treatments for tension-type headache published between 1966 and 1999. The 35 prospective and randomized trials that met all of the stringent research design and data extraction requirements; the 35 trials yielded the following 77 treatment groups: relaxation training, EMG biofeedback, EMG biofeedback plus relaxation, cognitive-behavioral therapy [stress-management training], waitlist control, and other controls. For comparison purposes, controlled trials of amitriptyline, arguably the most commonly prescribed medication for prophylaxis of tension-type headache, were identified. Interestingly, only three such trials could be identified in the published literature. As in the Goslin et al[62] review, treatment outcome data were calculated using two metrics: summary effect size estimates and average percentage improvement from pre- to posttreatment. Behavioral interventions for tension-type headache yielded 37% to 50% reduction in headache versus 2% reduction for no treatment, and 9% for other controls (Fig. 3). The effect size estimates indicated that all of the behavioral interventions statistically were more effective than waitlist control.

The meta-analysis by McCrory and colleagues[75] is the only one to employ highly selective study inclusion criteria for tension-type headache (similar to Goslin et al[62] for migraine). All other meta-analyses of the tension-type literature have been maximally inclusive of all available research.[76-78] Just the same, these earlier meta-analyses have reported findings that closely parallel the McCrory and colleagues'[75] review:

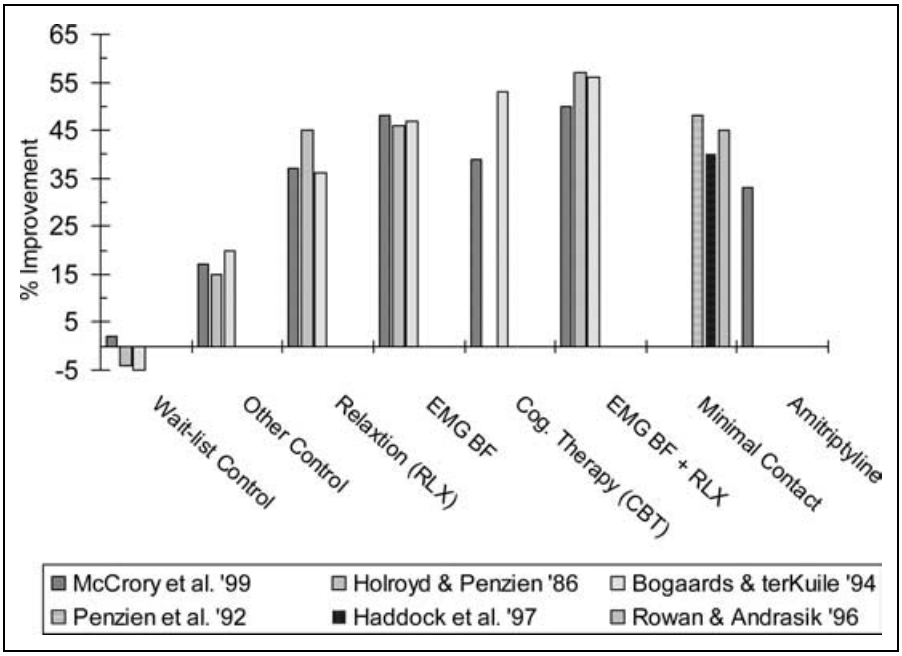

Fig 3.—Meta-analyses of behavioral and pharmacological treatments for tension-type headache: percentage improvement scores by treatment condition. RLX: relaxation training; BF: biofeedback; EMG: electromyographic; CBT: cognitive-behavioral treatment.

behavioral treatments for tension-type headache are efficacious (typically 35% to 55% headache reduction from pre- to posttreatment), and all treatment conditions statistically are more effective than control conditions (Fig. 3).

Even less evidence is available to address the comparative efficacy of pharmacologic versus behavioral therapies for tension-type than for migraine headache.[79-82] Because relatively few trials of medication prophylaxis for tension-type headache have been published to date, even meta-analytic techniques cannot shed much light on this issue. The three controlled studies of amitriptyline for tension-type headache reviewed by McCrory et al[75] have yielded, on average, a 33% reduction in headache activity, which is on the low end of the range achieved by behavioral therapies (Fig. 3). Perhaps the best available evidence addressing this issue is provided by the study of Holroyd et al,[83] which randomly assigned over 200 tension-type headache patients to one of four conditions: (i) tricyclic antidepressant medication, (ii) stress-management training, (iii) combined antidepressant and stress-management, or (iv) medication placebo. Medication and behavioral therapy each produced larger reductions in headache activity, analgesic medication use, and headache-related disability than placebo, but the medication condition yielded more rapid improvements in headache activity. The combined therapy was more likely to produce clinically meaningful reductions in headache (64% of patients) than either antidepressant medication (38%) or stress-management training (35%); whereas both treatment strategies are modestly effective, the combined therapy may improve outcomes.

As in the migraine literature, there is a sizeable amount of evidence indicating that, at least among those who respond initially, the effects of behavioral treatments endure over time, with the longest follow-up occurring after 7 years.[67] These effects endure whether further contact is provided (booster sessions) or not.[84] For example, Blanchard and colleagues[68] found that 78% of tension-type sufferers and 91% of migraine sufferers remained significantly improved 5 years following behavioral treatment. Likewise, a retrospective examination of nearly 400 headache patients who completed a comprehensive treatment program that included relaxation and biofeedback found that 65% reported maintaining their treatment gains.[85] Though retrospective, these results are presented here because of the large sample size and the fact that the data were collected within a clinical program (vs the more typical research program) and, as such, may address in vivo the issue of "effectiveness" (vs "efficacy").

Minimal-Contact Format.—The most comprehensive meta-analytic review of the minimal-contact (home-based) treatment literature was published by Haddock and colleagues.[55] The reviewers identified 20 prospective and randomized controlled trials published between 1977 and 1996, including five pediatric or adolescent studies. Studies of migraine (6 studies), tension-type (8 studies) and combined diagnosis (6 studies) were included in the review. Similar to the clinic-based behavioral treatments described above, minimal-contact treatments included: cognitive therapy, relaxation training, and in some instances abbreviated biofeedback components adapted for home use. Thirteen studies directly compared minimal-contact to standard clinic-based treatment, while nine trials compared minimal-contact to waitlist or attention control. The 13 direct study comparisons averaged 2.7 clinic visits (161.5 [SD = 79.9] minutes with therapist) for minimal-contact versus 8.6 (483.8 [SD = 164.6] minutes with therapist) for clinic-based. Treatment outcome data were calculated using effect size scores. For studies comparing minimal-contact to waitlist or attention control, minimal-contact treatment conditions were statistically more effective than control conditions. For studies comparing minimal-contact to clinic-based, minimal-contact was equivalent or superior to clinic-based treatment. The review also reported the percentage of patients clinically improved (ie, headache decreased $\geq$50%) for the 13 studies providing direct comparisons; for migraine, tension-type and combined diagnoses, respectively, minimal-contact (53.2%, 40.5%, 51.0%) was similar to clinic-based (52.5%, 41.5%, 42.9%) in the percentage of patients with a 50% or greater percentage headache change from pre- to posttreatment. Findings of the meta-analysis by Haddock and colleagues[55] were consistent with the earlier meta-analytic reviews of the minimal-contact treatment literature by Rowan and

Andrasik[57] and by Rains, Penzien, and Holroyd[56] (Figs. 2 and 3).

In a cost-conscious healthcare environment, *cost effectiveness* often is more important than *overall effectiveness* for widespread implementation of any given intervention. Haddock and colleagues[55] also employed meta-analytic techniques to evaluate the relative cost effectiveness of minimal-contact therapy relative to "standard" clinic-based behavioral therapy. Cost-effectiveness was calculated using the formula: [% improvement/clinician contact time]. The seven studies for which cost-effectiveness scores could be calculated demonstrated minimal contact to be five-fold more cost effective than clinic-based behavioral therapy. A more recent study[86] similarly revealed minimal-contact behavioral interventions to be the least expensive treatment option after 1 year, not only relative to clinic-based behavioral treatment, but also relative to even low-priced prophylactic headache medications.

Pediatric Migraine.—The pediatric headache literature includes fewer studies than the adult literature. Hermann and colleagues[87] identified a total of 38 behavioral and 34 pharmacological studies evaluating treatment of pediatric migraine published between 1970 and 1993; only 17 behavioral studies (31 separate treatment groups) and 24 drug studies (50 separate treatment groups) met inclusion criteria for meta-analysis. Behavioral treatments included: progressive relaxation training, autogenic training, autogenic plus progressive relaxation training, thermal biofeedback, thermal biofeedback plus progressive relaxation training, cognitive-behavioral treatment, cognitive therapy, waitlist control, and other controls. Pharmacologic treatments included: propranolol, calcium-channel blockers, serotonergic drugs, dopaminergic drugs, ergotamine, clonidine, and placebo. Although the authors acknowledged that the small number of studies in this literature substantially limited the conclusions that could be drawn, they concluded that there was sufficient evidence to indicate that thermal biofeedback and interventions combining biofeedback and progressive relaxation training were superior to other behavioral treatments, the more commonly used prophylactic drug treatments and placebo. Hermann and colleagues[87] also concluded that there was some indication of effectiveness of propranolol for treatment of pediatric migraine, but the small number of studies precluded a more definitive conclusion.

A more recent review examined the effectiveness of behavioral treatment in pediatric versus adult headache sufferers (migraine and tension-type headache).[88] This meta-analysis of the biofeedback training literature demonstrated a marked headache improvement following thermal and EMG biofeedback among children (aged 7 to 19 years). The response among children was greater than the response observed among adults. Headache improvement across pediatric studies averaged 62% and 81% for thermal and EMG biofeedback, respectively, versus 34% and 48% for adults.

METHODOLOGICAL CRITIQUE

In evaluating the clinical applicability and methodological quality of the trial literature on behavioral therapies for headache, it is natural to draw comparisons with the much larger body of research on pharmacologic treatments for headache. The two bodies of research differ in many respects, yet share some common problems.

The main issues to be discussed in relation to behavioral trials concern the recruitment and selection of subjects; sample size and statistical power; the use of a credible control; and the reproducibility of the interventions studied. Some of the problems described below are specific to trials of behavioral interventions (eg, difficulty of blinding), while others also pertain to drug treatment trials (eg, defining clinically significant improvement); still others might be described as "cultural" problems (eg, the lack of integration of behavioral and medical populations). Table 2 lists methodologic considerations addressed in this critique and provides citations to articles further addressing these issues within a special series of papers addressing headache research methodology published in *Headache* as a companion to this supplement.

Recruitment of Subjects.—One important concern in interpreting the behavioral therapy trial literature is that there may be some bias in the selection of subjects. Subjects for studies of behavioral therapies are often recruited from nonmedical populations using means such as newspaper or other media advertisements.

Table 2.—Methodological Consideration in Behavioral Headache Trials

Sample
Representativeness of the sample (nonclinical populations, specialty headache, and chronic pain clinics)[96]
Generalizability to majority populations (especially average headache patients in primary care)[113]
Classification by headache diagnosis to conform to standard prevailing diagnostic nosology[110]
Design
Sample size and statistical power (power analysis)[106]
Statistically versus clinically significant change[96]
Trial designs employing small samples[107,109,111]
Control groups[19,111]
Blinding or masking [and controlling bias when blinding is not possible or feasible][19]
Outcome measures and headache-related variables of interest[12,108,114,115]
Treatment
Treatment integrity[113]
Generalizability (transportability and availability) to clinical practice[115]
Comparability with medical standard of care[112]
Interactions with pharmacologic treatments for headache prevention[112]

This was the case, for example, in nearly half of the studies reviewed by Goslin and colleagues.[62] Data on headache sufferers who may not have sought medical care are important, since studies have shown that a substantial proportion of people with migraine remain undiagnosed or do not seek care from a physician.[89,90] However, the recruitment of patients from nonmedical populations is one factor that limits comparison between behavioral and drug trials. Furthermore, some behavioral trials use quite narrow populations, such as undergraduate university students, as a recruiting pool, which further limits the generalizability of their findings to clinical populations.

Any bias in the populations studied (eg, an aversion to drug therapy, a preference for psychological therapy, associated anxiety or other comorbid conditions) could limit the generalizability of data from behavioral trials to other populations. There are, however, few empirical data to support the notion that substantial biases of this sort exist.

Selection of Subjects.—*Diagnostic Specificity.*— Subjects in behavioral treatment trials are often not characterized using clinical diagnoses that are as specific as would be desirable, although this has improved in recent years. The lack of sufficient specificity in headache diagnosis is, in part, a result of changes over the years in the formal criteria used to diagnose headache. These criteria have developed and changed a great deal from the Ad Hoc criteria of 1962[91] to the first[92] and second[93] editions of the International Classification of Headache Disorders (ICHD). In general, the trend has been to move from a few broad categories that were rather vaguely defined to a large number of more specific diagnoses with precise criteria.

In addition to these changes in the diagnostic criteria, however, there was also a tradition in the early behavioral headache literature of regarding specific headache diagnoses as relatively unimportant, because the conceptual model guiding such therapies suggested that their effects were independent of any specific headache disorder. Patients were often recruited on the basis of frequent headache symptoms alone, regardless of their particular headache diagnosis. Indeed, subjects were often recruited from a nonmedical setting, and sometimes did not have an existing medical diagnosis or did not receive one as part of their involvement in the study.

Part of the problem has been that the existing formal diagnostic criteria have not dealt very effectively with patients of the type often included in behavioral treatment trials, namely, patients with very frequent headaches with migrainous features, or which seemed to evolve from episodic migraine. Such patients have been classified in the most recent version of the ICHD.[93]

Sample Size and Power.—In general, trials of behavioral therapies for headache are relatively small. Although they may have sufficient power to demonstrate a statistically significant difference, they rarely specify a minimal clinically important difference for the main outcome measure on which power calculations might be based. Thus, even when statistically significant differences are found, the clinical importance of these findings often remains uncertain. For example, the most commonly reported outcome measures in behavioral trials have been headache frequency and headache index, most often analyzed as continuous variables. Occasionally, data on these outcomes have been used to calculate the proportion of patients

experiencing a 50% or greater reduction in headache frequency or headache index.[84,94,95] These generally are recognized as clinically relevant outcomes.[96] Unfortunately, dichotomous outcomes of this sort are less efficient in that they require larger sample size to demonstrate a statistically significant result. Similar problems result when different components of behavioral treatment are assessed to test whether combined behavioral approaches are better than single modes. Small studies, which often fail to find statistically significant differences between combined and single modalities, sometimes lead to the conclusion that there is no difference between them, when in fact small sample sizes and low statistical power may mask clinically important differences. Acknowledging these problems relating to small sample sizes, researchers in many trials have made study design modifications to improve statistical power, given limited sample sizes. For example, many behavioral studies use within-sample matching techniques when assigning subjects to treatment groups (to ensure equivalence of groups on important independent variables).[97-99] This serves to reduce variance and increase statistical power.

Use of a Credible Control.—Treatment efficacy research involves demonstrating a statistically and clinically significant benefit of treatment while controlling patient and experimenter bias as well as nonspecific treatment effects. Usually, such research involves comparison of active treatment(s) with a credible active control condition, ideally with blinding. By far the most common control used in behavioral treatments trials is an inactive waitlist condition. The less common "placebo," or active control, conditions include a variety of experimental conditions designed to improve the validity of the comparison by single-blinding or double-blinding, or by providing a credible alternative therapy with no therapeutic value. Examples from the behavioral headache literature have included pseudomeditation,[100] a placebo pill (subjects were misled that it was an effective muscle relaxant),[101] or sham biofeedback (altered contingency or noncontingent EMG biofeedback).[102] The magnitude of the effect of such placebo or active control conditions is small, having an effect size estimated at 0.15, which was not statistically different from the waitlist control in two meta-analyses.[62,75] That is, the "placebo" effect was not large enough to rival the treatment effects of behavioral therapies in the same sets of studies.

Double-blinding is impossible for most behavioral interventions, and effective single-blinding is also difficult to achieve in most cases.[19] The use of waitlist controls (rather than credible placebos) and the lack of blinding make behavioral trials more prone to bias than traditionally designed drug trials, and more likely to find a spurious statistically significant result.

Reproducibility of the Intervention.—Behavioral therapies, as described above, are fairly complex interventions. Issues such as therapist training, integrity of treatment, and compliance all serve to complicate the reproducibility and transportability of a behavioral intervention. A few trials have empirically studied different methods of delivering behavioral therapies, testing the importance of home practice,[94,103] intensity of therapist contact,[104] and booster training.[84] However, many aspects of the delivery of therapy remain inadequately studied, and variations in these therapies due to personnel, setting, and other factors may partially determine whether the intervention will work as well in practice as in trials.

CONCLUSIONS

Since its genesis in the mid-20th century, behavioral headache research has grown, matured scientifically, and despite methodological imperfections has yielded impact on contemporary headache management. The past three decades have amassed a considerable evidence base addressing behavioral headache treatments. This literature exhibited unprecedented growth in the 1970s and early 1980s stimulated by the development of biofeedback treatments for headache. Although the number of psychophysiology and biofeedback studies has declined in recent years, behavioral headache research productivity has continued to grow in both number and breadth of studies. Publication trends show greater proportions of controlled than uncontrolled trials, and assessment of a broadening range behavioral and functional variables pertinent to average headache sufferer.

Meta-analytic literature reviews of behavioral interventions (relaxation training, biofeedback, cognitive-behavioral therapy) have consistently shown behavioral therapies to be effective treatments for

primary headache. Across studies, behavioral interventions have yielded approximately a 35% to 55% reduction in migraine and tension-type headache parameters. Although direct comparisons of behavioral and pharmacologic treatments for headache are few, the available evidence suggests that the level of headache improvement with behavioral interventions may rival those obtained with widely used pharmacologic therapies in representative patient samples.

Clinical trials research is evolving with comparisons to standard pharmacologic treatments, broader populations (eg, pediatric, elderly), and cost-effective applications (minimal-contact or home-based formats). It should be noted, there are preliminary studies of additional, novel applications that were not addressed in this overview because of the limited evidence but are discussed elsewhere[2,105] (eg, Internet-facilitated interventions, self-management training programs designed for physician practice settings).

Although research has yielded solid empirical foundations for behavioral headache treatments, this literature is not without methodologic limitations. Certain methodologic criticisms presented here apply uniquely or disproportionately to behavioral trials, while others might apply as well to pharmacologic headache trials. Most behavioral treatments, by virtue of the inherent therapeutic relationship and psychological change process, cannot be blinded, crossed over or placebo controlled; thus, there are unique research design challenges in controlling bias.[19] As referenced in Table 2, many of the methodologic considerations addressing recruitment, design, and treatment in behavioral research have been addressed in the guideline for behavioral trials published in this supplement and expounded in the related series of papers published in the companion issue of the journal.[12,19,106-114] Nevertheless, assessment of the sum of the literature has yielded endorsements for behavioral headache treatments by numerous professional organizations (Table 1).

Despite substantial growth, endorsement, and increasing integration of behavioral headache treatments into headache management, there remain substantial opportunities to strengthen and expand both the research base and clinical application of these therapies. Future directions are discussed in detail elsewhere[115] and *Guidelines for Trials of Behavioral Treatments for Recurrent Headache*[96] were published to facilitate production of high-quality research. Likely, current treatments represent only a fraction of what is possible in the application of behavioral and psychological principals to headache.

REFERENCES

1. Penzien DB, Rains JC, McGrath PJ. Psychological and behavioral treatments of migraine. In: Olesen J, Goadsby P, Ramadan N, Tfelt-Hansen P, Welch KMA, eds. The Headaches, 3rd ed. Philadelphia, PA: Lippincott, Williams, & Wilkins; in press.
2. Penzien DB, Rains JC, Andrasik F. Behavioral management of recurrent headache: three decades of experience and empiricism. *Appl Psychophysiol Biofeedback*. 2002;27:163-181.
3. Wolff HG. Life stress and bodily disease: a formulation. *Res Publ Assoc Res Nerv Ment Dis*. 1949;29:1059-1094.
4. Wolff HG. Stress and Disease. Springfield, IL: Charles C. Thomas; 1953.
5. Simmons LW, Wolff HG. Social Science in Medicine. New York: Russell Sage Foundation; 1954.
6. Friedman AP, Brenner C. Psychological mechanisms in chronic headache. *Res Publ Assoc Res Nerv Ment Dis*. 1949;29:605-608.
7. Cannon WB. Bodily Changes in Pain, Hunger, Fear, and Rage: An Account of Recent Researches Into the Function of Emotional Excitement. New York: Appleton; 1915.
8. Cannon WB. Stresses and strains of homeostasis (Mary Scott Newbold Lecture). *Am J Med Sci*. 1935;189:1-14.
9. Selye H. A syndrome produced by diverse nocuous agents. *Nature*. 1936;138:32. [Reprinted in: Neylan J. Hans Selye and the Field of Stress Research *J Neuropsychiatry Clin Neurosci*. 1998;10(2):230-231].
10. Selye H, Fortier C. Adaptive reactions to stress. *Res Publ Assoc Res Nerv Ment Dis*. 1949;29:3-18.
11. Selye H. The Physiology and Pathology of Exposure to Stress. A Treatise Based on the Concepts of the General-Adaptation-Syndrome and the Diseases of Adaptation. Montreal: Acta Inc. Medical Publishing; 1950.

12. Lake AE III, Rains JC, Penzien DB, Lipchik GL. Headache and psychiatric comorbidity: historical context, clinical implications, and research relevance. *Headache*. 2005;45:493-506.
13. Engel GL. The need for a new medical model: a challenge for biomedicine. *Science*. 1977;196:129-136.
14. Weiner H. Praise be to psychosomatic medicine. *Psychosom Med*. 1999;61:259-262.
15. Schwartz GE, Weiss SM. Behavioral medicine revisited: an amended definition. *J Behav Med*. 1978;1:249-251.
16. Shapiro D, Schwartz GE. Biofeedback and visceral learning: clinical applications. *Semin Psychiatry*. 1972;4:171-184.
17. Keefe FJ, Lumley MA, Buffington AL, et al. Changing face of pain: evolution of pain research in psychosomatic medicine. *Psychosom Med*. 2002;64:921-938.
18. Simons DW, Wolff HG. Studies on headache: mechanisms of chronic and post-traumatic headache. *Psychosom Med*. 1946;8:227-242.
19. Rains JC, Penzien DB. Behavioral research and the double-blind placebo-controlled methodology: challenges in applying the biomedical standard to behavioral headache research. *Headache*. 2005;45:479-486.
20. Budzynski TH, Stoyva JM. An instrument for producing deep muscle relaxation by means of analog information feedback. *J Appl Behav Anal*. 1969;2:231-237.
21. Budzynski TH, Stoyva JM, Adler C. Feedback-induced muscle relaxation: applications to tension headache. *J Behav Ther Exp Psychiat*. 1970;1:205.
22. Budzynski TH, Stoyva JM, Adler CS, Mullaney DJ. EMG biofeedback and tension headache: a controlled outcome study. *Psychosom Med*. 1973;35:484-496.
23. Sargent JD, Green EE, Walters ED. The use of autogenic feedback training in a pilot study of migraine and tension headaches. *Headache*. 1972;12:120-124.
24. Blanchard EB, Theobald DE, Williamson DA, Silver BV, Brown DA. Temperature biofeedback in the treatment of migraine headaches: a controlled evaluation. *Arch Gen Psychiatry*. 1978;35:581-588.
25. Diamond S, Medina J, Diamond-Falk J, DeVeno T. The value of biofeedback in the treatment of chronic headache: a five-year retrospective study. *Headache*. 1979;19:90-96.
26. Duckro PN, Tait R, Margolis RB, Silvermintz S. Behavioral treatment of headache following occupational trauma. *Headache*. 1985;25:328-331.
27. Gauthier J, Bois R, Allaire D, Drolet M. Evaluation of skin temperature biofeedback training at two different sites for migraine. *J Behav Med*. 1981;4:407-419.
28. Holroyd KA, Andrasik F. Coping and the self-control of chronic tension headache. *J Consult Clin Psychol*. 1978;46:1036-1045.
29. Holroyd KA, Penzien DB, Hursey KG, et al. Change mechanisms in EMG biofeedback training: cognitive changes underlying improvements in tension headache. *J Consult Clin Psychol*. 1984;52:1039-1053.
30. Jurish SE, Blanchard EB, Andrasik F, Teders SJ, Neff DF, Arena JG. Home- versus clinic-based treatment of vascular headache. *J Consult Clin Psychol*. 1983;51:743-751.
31. Lake A, Rainey J, Papsdorf JD. Biofeedback and rational-emotive therapy in the management of migraine headache. *J Appl Behav Anal*. 1979;12:127-140.
32. Mathew NT. Prophylaxis of migraine and mixed headache. A randomized controlled study. *Headache*. 1981;21:105-109.
33. Mitchell KR, White RG. Control of migraine headache by behavioral self-management: a controlled case study. *Headache*. 1976;16:178-184.
34. Saper JR. Migraine. II. Treatment. *JAMA*. 1978;239:2480-2484.
35. Sovak M, Kunzel M, Sternbach RA, Dalessio DJ. Is volitional manipulation of hemodynamics a valid rationale for biofeedback therapy of migraine? *Headache*. 1978;18:197-202.
36. Weeks R, Baskin S, Sheftell F, Rapoport A, Arrowsmith F. A comparison of MMPI personality data and frontalis electromyographic readings in two groups of daily headache sufferers. *Headache*. 1983;23:83-85.
37. Jacobson E. Progressive Relaxation: A Physiological and Clinical Investigation of Muscular States and Their Significance in Psychology and Medical Practice. Chicago: University of Chicago Press; 1929.
38. Jacobson E. Progressive Relaxation. Chicago: University of Chicago Press; 1934.
39. Bernstein DA, Borkovec TD. Progressive Relaxation Training: A Manual for the Helping Professions. Champaign, IL: Research Press; 1973.

40. Bernstein DA, Borkovec TD, Hazlett-Stevens H. New Directions in Progressive Relaxation Training: A Guidebook for Helping Professionals. Westport, CT: Praeger Publishers; 2000.
41. Schultz J, Luthe W. Autogenic Training: A Psychophysiologic Approach to Psychotherapy, Vol. 1. New York: Grune & Stratton; 1959.
42. Benson H. The Relaxation Response. New York: William Morrow & Co; 1975.
43. Benson H, Klemchuk HP, Graham JR. The usefulness of the relaxation response in the therapy of Headache. *Headache*. 1974;14:49-52.
44. Zitman FG, van Dyck R, Spinhoven P, Linssen AC. Hypnosis and autogenic training in the treatment of tension headaches: a two-phase constructive design study with follow-up. *J Psychosom Res*. 1992;36:219-228.
45. ter Kuile MM, Spinhoven P, Linssen AC. Responders and nonresponders to autogenic training and cognitive self-hypnosis: prediction of short- and long-term success in tension-type headache patients. *Headache*. 1995;35:630-636.
46. ter Kuile MM, Spinhoven P, Linssen AC, Zitman FG, van Dyck R, Rooijmans HG. Autogenic training and cognitive self-hypnosis for the treatment of recurrent headaches in three different subject groups. *Pain*. 1994;58:331-340.
47. Spiegel D, Moore R. Imagery and hypnosis in the treatment of cancer patients. *Oncology (Huntingt)*. 1997;11:1179-1195.
48. Ludwig AM. An historical survey of the early roots of mesmerism. *Int J Clin Exp Hypn*. 1964;12:205-217.
49. Beck AT. Cognitive Therapy and the Emotional Disorders. New York: International Universities Press; 1979.
50. Ellis A. Reason and Emotion in Psychotherapy. New York: Lyle Stuart; 1962.
51. Meichenbaum DH. Stress Inoculation Training. St. Louis, MO: Elsevier Science & Technology Books; 1985.
52. Holroyd KA, Andrasik F. A cognitive-behavioral approach to recurrent tension and migraine headache. In: Kendall PE, ed. Advances in Cognitive-Behavioral Research and Therapy. New York: Academic Press; 1982.
53. Holroyd KA, Holm JE, Penzien DB. Clinical issues in the behavioral treatment of recurrent headache. In: Keller PA, Heyman SR, eds. Innovations in Clinical Practice: A Source Book, Vol. 7. Sarasota, FL: Professional Resource Exchange; 1988:433-457.
54. Blanchard EB, Andrasik F. Management of Chronic Headaches: A Psychological Approach. New York, NY: Pergamon Press; 1985.
55. Haddock CK, Rowan AB, Andrasik F, Wilson PG, Talcott GW, Stein RJ. Home-based behavioral treatments for chronic benign headache: a meta-analysis of controlled trials. *Cephalalgia*. 1997;17:113-118.
56. Rains JC, Penzien DB, Holroyd JE. Meta-analysis of alternative behavioral treatments for recurrent headache. *Headache*. 1993;33:279-280.
57. Rowan AB, Andrasik F. Efficacy and cost-effectiveness of minimal therapist contact treatments for chronic headache: a review. *Behav Ther*. 1996;27:207-234.
58. Board of Directors AASH. Biofeedback therapy. *Headache*. 1978;18:107.
59. McCrory DC, Matchar DB, Gray RN, Rosenberg JH, Silberstein SD. Evidence-based guidelines for migraine headache: overview of program description and methodology. November 1999. Prepared for the US Headache Consortium. Available at: http://www.aan.com/professionals/practice/pdfs/gl0086.pdf; see "Headache – Tools." Accessed February 9, 2005.
60. Silberstein SD. Practice parameter: evidence-based guidelines for migraine headache (an evidence-based review): report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology*. 2000;55:754-762.
61. Campbell JK, Penzien DB, Wall EM. Evidence-based guidelines for migraine headache: behavioral and physical treatments. November 1999. Prepared for the US Headache Consortium. Available at: http://www.aan.com/professionals/practice/pdfsgl0089.pdf; see "Headache – Tools." Accessed February 9, 2005.
62. Goslin RE, Gray RN, McCrory DC, Penzien D, Rains J, Hasselblad V. Behavioral and physical treatments for migraine headache. Technical review 2.2. February 1999. Prepared for the Agency for Health Care Policy and Research under Contract No. 290-94-2025. Available at: http://www.clinpol.mc.duke.edu (follow link to "Publications"). Accessed February 9, 2005.
63. Blanchard EB, Andrasik F, Ahles TA, Teders SJ, O'Keefe D. Migraine and tension-type headache: a meta-analytic review. *Behav Ther*. 1980;11:613-631.

64. Blanchard EB, Andrasik F. Psychological assessment and treatment of headache: recent developments and emerging issues. *J Consult Clin Psychol*. 1982;50:859-879.
65. Holroyd KA, Penzien DB. Pharmacological vs. nonpharmacological prophylaxis of recurrent migraine headache: a meta-analytic review of clinical trials. *Pain*. 1990;42:1-13.
66. Penzien DB, Holroyd KA, Holm JE, Hursey KG. Behavioral management of migraine: results from five-dozen group outcome studies. *Headache*. 1985;25:162.
67. Blanchard EB. Psychological treatment of benign headache disorders. *J Consult Clin Psychol*. 1992;60:537-551.
68. Blanchard EB, Appelbaum KA, Guarnieri P, Morrill B, Dentinger MP. Five year prospective follow-up on the treatment of chronic headache with biofeedback and/or relaxation. *Headache*. 1987;27:580-583.
69. Holroyd KA, Holm JE, Hursey KG, et al. Recurrent vascular headache: home-based behavioral treatment vs. abortive pharmacological treatment. *J Consult Clin Psychol*. 1988;56:218-223.
70. Penzien DB, Johnson CA, Carpenter DE, Holroyd KA. Drug vs. behavioral treatment of migraine: long-acting propranolol vs. home-based self-management training. *Headache*. 1990;30:300.
71. Sartory G, Muller B, Metsch J, Pothmann R. A comparison of psychological and pharmacological treatment of pediatric migraine. *Behav Res Ther*. 1998;36:1155-1170.
72. Sovak M, Kunzel M, Sternbach RA, Dalessio DJ. Mechanism of the biofeedback therapy of migraine: volitional manipulation of the psychophysiological background. *Headache*. 1981;21:89-92.
73. Davis MK, Holroyd KA, Penzien DB. Flunarizine and propranolol: comparative effectiveness in the treatment of migraine headaches. *Headache*. 1999;39:349.
74. Holroyd KA, Penzien DB, Cordingley GA. Propranolol in the prevention of recurrent migraine: a meta-analytic review. *Headache*. 1991;31:333-340.
75. McCrory DC, Penzien DB, Hasselblad V, Gray RN. Evidence Report: Behavioral and Physical Treatments for Tension-Type and Cervicogenic Headache. Des Moines, IA: Foundation for Chiropractic Education and Research; 2001. Product No.: 2085.
76. Blanchard EB, Andrasik F, Ahles TA, Teders SJ, O'Keefe D. Migraine and tension-type headache: a meta-analytic review. *Behav Ther*. 1980;11:613-631.
77. Bogaards MC, ter Kuile MM. Treatment of recurrent tension headache: a meta-analytic review. *Clin J Pain*. 1994;10:174-190.
78. Holroyd KA, Penzien DB. Client variables and the behavioral treatment of recurrent tension headache: a meta-analytic review. *J Behav Med*. 1986;9:515-536.
79. Bruhn P, Olesen J, Melgaard B. Controlled trial of EMG feedback in muscle contraction headache. *Ann Neurol*. 1979;6:34-36.
80. Holroyd KA, O'Donnell FJ, Stensland M, Lipchik GL, Cordingley GE, Carlson BW. Management of chronic tension-type headache with tricyclic antidepressant medication, stress management therapy, and their combination: a randomized controlled trial. *JAMA*. 2001;285:2208-2215.
81. Holroyd KA, Nash JM, Pingel JD, Cordingley GE, Jerome A. A comparison of pharmacological (amitriptyline HCL) and nonpharmacological (cognitive-behavioral) therapies for chronic tension headaches. *J Consult Clin Psychol*. 1991;59:387-393.
82. Reich BA, Gottesman B. Biofeedback and psychotherapy in the treatment of muscle contraction/tension-type headache. In: Tollison CD, Kunkel RS, eds. Headache: Diagnosis and Treatment. Baltimore: Williams and Wilkins; 1993:167-183.
83. Holroyd KA, O'Donnell FJ, Stensland M, Lipchik GL, Cordingley GE, Carlson BW. Management of chronic tension-type headache with tricyclic antidepressant medication, stress management therapy, and their combination: a randomized controlled trial. *JAMA*. 2001;285:2208-2215.
84. Andrasik F, Blanchard EB, Neff DF, Rodichok LD. Biofeedback and relaxation training for chronic headache: a controlled comparison of booster treatments and regular contacts for long-term maintenance. *J Consult Clin Psychol*. 1984;52:609-615.
85. Diamond S, Montrose D. The value of biofeedback in the treatment of chronic headache: a four-year retrospective study. *Headache*. 1984;24:5-18.
86. Mulkana SS, Penzien DB, Houle TT, Rains JC, Freidenberg BM. Expense of preventative drug and behavioral headache therapies: an expanded analysis (abstract). *Headache*. 2004;44:515.

87. Hermann C, Kim M, Blanchard EB. Behavioral and pharmacological intervention studies of pediatric migraine: an exploratory meta-analysis. *Pain*. 1995;60:239-256.
88. Sarafino EP, Goehring BA. Age comparisons in acquiring biofeedback control and success in reducing headache pain. *Ann Behav Med*. 2000;22:10-16.
89. Lipton RB, Stewart WF, Simon D. Medical consultation for migraine: results from the American Migraine Study. *Headache*. 1998;38:87-96.
90. Lipton RB, Diamond S, Reed M, Diamond ML, Stewart WF. Migraine diagnosis and treatment: results from the American Migraine Study II. *Headache*. 2001;41:638-645.
91. Ad Hoc Committee on the Classification of Headache of the National Institute of Neurological Diseases and Blindness. Classification of headache. *JAMA*. 1962;179:717-718.
92. Headache Classification Committee of the International Headache Society. Classification and diagnostic criteria for headache disorders, cranial neuralgias and facial pain. *Cephalalgia*. 1988;8(suppl 7):1-96.
93. Headache Classification Subcommittee of the International Headache Society. The international classification of headache disorders: 2nd edition. *Cephalalgia*. 2004;24(suppl 1):1-160.
94. Blanchard EB, Nicholson NL, Radnitz CL, Steffek BD, Appelbaum KA, Dentinger MP. The role of home practice in thermal biofeedback. *J Consult Clin Psychol*. 1991;59:507-512.
95. Blanchard EB, Appelbaum KA, Guarnieri P, et al. Two studies of the long-term follow-up of minimal therapist contact treatments of vascular and tension headache. *J Consult Clin Psychol*. 1988;56:427-432.
96. Penzien DB, Andrasik F, Freidenberg BM, et al. Guidelines for trials of behavioral treatments for recurrent headache. *Headache*. 2005;45(suppl 2):S110-S132.
97. Holroyd KA, Nash JM, Pingel JD. A comparison of pharmacological (amitriptyline HCL) and nonpharmacological (cognitive-behavioral) therapies for chronic tension headaches. *J Consult Clin Psychol*. 1991;59:387-393.
98. Mosley TH, Grothues CA, Meeks WM. Treatment of tension headache in the elderly: a controlled evaluation of relaxation training and relaxation training combined with cognitive-behavior therapy. *J Clin Geropsychol*. 1995;1:175-188.
99. Rokicki LA, Holroyd KA, France CR, Lipchik GL, France JL, Kvaal SA. Change mechanisms associated with combined relaxation/EMG biofeedback training for chronic tension headache. *Appl Psychophysiol Biofeedback*. 1997;22:21-41.
100. Blanchard EB, Appelbaum KA, Radnitz CL, et al. Placebo-controlled evaluation of abbreviated progressive muscle relaxation and of relaxation combined with cognitive therapy in the treatment of tension headache. *J Consult Clin Psychol*. 1990;58:210-215.
101. Cox DJ, Freundlich A, Meyer RG. Differential effectiveness of electromyograph feedback, verbal relaxation instructions, and medication placebo with tension headaches. *J Consult Clin Psychol*. 1975;43:892-898.
102. Paiva T, Nunes JS, Moreira A, Santos J, Teixeira J, Barbosa A. Effects of frontalis EMG biofeedback and diazepam in the treatment of tension headache. *Headache*. 1982;22:216-220.
103. Gauthier J, Côté G, French D. The role of home practice in the thermal biofeedback treatment of migraine headache. *J Consult Clin Psychol*. 1994;62:180-184.
104. Richardson GM, McGrath PJ. Cognitive-behavioral therapy for migraine headaches: a minimal-therapist-contact approach versus a clinic-based approach. *Headache*. 1989;29:352-357.
105. Penzien DB, Rains JC, Lipchik GL, Creer TL. Behavioral interventions for tension-type headache: overview of current therapies and recommendation for a self-management model for chronic headache. *Curr Pain Headache Rep*. 2004;8:489-499.
106. Houle TT, Penzien DB, Houle CK. Statistical power and sample size estimation for headache research: an overview and power calculation tools. *Headache*. in press.
107. Lipchik GL, Nicholson RA, Penzien DB. Allocation of patients to conditions in headache clinical trials: randomization, stratification, and treatment matching. *Headache*. 2005;45:419-428.
108. Andrasik F, Lipchik GL, McCrory DC, Wittrock DA. Outcome measurement in headache research: headache parameters and psychosocial outcomes. *Headache*. 2005;45:429-437.
109. Houle TT, Remble TA, Houle TA. The examination of headache activity using time series research designs. *Headache*. 2005;45:438-444.

110. McCrory DC, Gray RN, Tfelt-Hansen P, Steiner TJ, Taylor FR. Methodological issues in systematic reviews of headache trials: adapting historical diagnostic classifications and outcome measures to present day standards. *Headache*. 2005;45:459-465.
111. Hursey KG, Rains JC, Penzien DB, Nash JM, Nicholson RA. Behavioral headache research: methodologic considerations and research design alternatives. *Headache*. 2005;45:466-478.
112. Holroyd KA, Powers SW, Andrasik F. Methodological issues in clinical trials of drug and behavior therapies. *Headache*. 2005;45:487-492.
113. Nash JM, McCrory D, Nicholson RA, Andrasik F. Efficacy and effectiveness approaches in behavioral treatment trials. *Headache*. 2005;45:507-512.
114. Nicholson RA, Hursey KG, Nash JM. Moderators and mediators of behavioral intervention for headache. *Headache*. 2005;45:513-519.
115. Penzien DB, Rains JC, Lipchik GL, Nicholson RA, Lake AE, Hursey KG. Future directions in behavioral headache research: applications for an evolving healthcare environment. *Headache*. 2005;45:526-534.
116. Health and Public Policy Committee, American College of Physicians. Biofeedback for headaches. *Ann Intern Med*. 1985;102:128-131.
117. Diagnostic and therapeutic technology assessment. Biofeedback. *JAMA*. 1983;250:2381.
118. Association for Advancement of Behavior Therapy. Fact Sheet on Headache. 1988. Available at: http://www.aabt.org/publication/.
119. Association for Applied Psychophysiology and Biofeedback. Biofeedback and psychophysiology: efficacy. 2005. Available at: http://www.aapb.org/i4a/pages/index.cfm?pageid=3336.
120. Pryse-Phillips WE, Dodick DW, Edmeads JG, et al. Guidelines for the diagnosis and management of migraine in clinical practice. Canadian Headache Society. *CMAJ*. 1997;156:1273-1287.
121. Pryse-Phillips WE, Dodick DW, Edmeads JG, et al. Guidelines for the nonpharmacologic management of migraine in clinical practice. Canadian Headache Society. *CMAJ*. 1998;159:47-54.
122. Integration of behavioral and relaxation approaches into the treatment of chronic pain and insomnia. *NIH Technol Assess Statement*. 1995;16-18:1-34.
123. NIH Technology Assessment Panel. Integration of behavioral and relaxation approaches into the treatment of chronic pain and insomnia. *JAMA*. 1996;276:313-318.
124. Holroyd KA, Penzien DB. Self-Management of Recurrent Headache. Geneva, Switzerland: World Health Organization; 1993.