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SPECIAL SECTION

Multi-Modal Assessment and Treatment of Chronic Headache: The First in a Series of Case Studies

A Case Study: 30-Year Migraine Headache

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The treatment of headache is challenging, and is made more so by the fragmentation of medicine into clinical specialties. Physiologically, migraine headache is a systemic event, affecting multiple neurophysiological systems. Treatment often calls for a multidisciplinary approach. Research supports the efficacy of both general biofeedback and, to a lesser extent, neurofeedback in the treatment of headache, including migraine. Abnormal electrophysiological patterns, detectable with quantitative EEG, are frequently found in patients with migraine, especially after closed head injury. Research has also shown the frequent presence of trigger point activity in several areas of the musculature of the head and neck in headache patients, including those with migraine. Finally, the role of stress has been reported in the onset and exacerbation of headache pain. The authors provide a case study showing the application of quantitative EEG, surface electromyography (SEMG), and psychophysiological stress profiling in the assessment of a 56-year-old female with closed head injury and migraine headache. The treatment included myofascial massage with trigger point release, SEMG training to balance asymmetric muscle tension patterns, and a stress management program, including guided visualization and breath training. This comprehensive intervention produced a significant reduction in headache symptoms and an improvement in work productivity.

Introduction

The assessment and treatment of headache is a complex issue, as several different sources of pain may potentially be involved. These sources may include vascular components, damaged vertebral bodies, damage to the brain, muscular components (trigger points), and stress.

Because many health care professionals have only one area of specialization, they are often unable to provide a comprehensive headache evaluation without referring the headache patient to other specialists. This restriction to one's area of specialization can also affect research on treatment techniques for headache. However, it is unlikely that a single treatment will be effective for all types of headache.

Yucha and Montgomery (2008), in reviewing the research on adult headache, migraines, tension, or mixed types, reported numerous studies that showed that most surface electromyographic (SEMG) biofeedback training techniques led to positive outcomes. Successful reduction of symptoms using thermal biofeedback techniques (Silberstein, 2000; Conner & Rideout, 2005) has also been reported in the literature. More recently, successful headache treatment outcomes have been reported with electroencephologic (EEG) neurofeedback techniques (Walker, 2011). It appears that all forms of biofeedback have shown some success in treating headache (Nestoriuc et al., 2008), but more research is needed to identify which techniques, and combinations of techniques, are most successful with which types of headache. Therefore, it is important for the clinician to perform a careful diagnostic screening in order to select the most appropriate treatment approach that will produce the best clinical outcomes.

This paper discusses three areas of biofeedback for the treatment of headache: (a) EEG neurofeedback, (b) SEMG biofeedback, and (c) peripheral psychophysiology biofeedback (mainly temperature and Galvanic Skin Response).

Causes of Headache

Closed Head Injury

Headache is the most commonly reported symptom related to closed head injury (Browndyke, 2002; NINDS, 2012). According to Brown et al. (1994), there are two million people in the United States suffering from headache following mild traumatic brain injury. Of those people with mild traumatic brain injury, the authors suggested that between 30% and 80% suffered from headache pain. In a review of 23 traumatic brain injury (TBI) studies, Nampiaparampil (2008) found that chronic headache was prevalent in 57.8% of all individuals, which included mild to severe levels of injury. The author also found that among all levels of TBI, individuals with mild TBI most frequently reported experiencing chronic pain (78%). Barnat (1986) indicated that there was little pattern in the demographics of posttraumatic headache patients, with males comprising 46% with an average age of 37.0 years, while females averaged 38.4 years in age. Thus it appears that headache is highly related to closed head injury.

Quantitative electroencephalography (QEEG) is useful for determining the impact of a closed head injury, including the potential underlying causes of headache. QEEG is a diagnostic tool that provides a direct measurement of cortical functioning (Thatcher et al., 2001). The computerized processing of EEG data allows clinicians to obtain precise measures, such as coherence and phase, which are typically the strongest indicators of cognitive functioning (Thatcher et al., 2005). Specifically, increases in slow-wave EEG amplitudes are frequently linked with headache (Thomaides et al., 2008). From a relative standpoint, this finding may relate to the observation that brain injury typically involves decreased amplitudes in the higher frequencies of the EEG (Thatcher, 1999).

However, Walker (2011) when assessing 71 patients (ages 17–62) with recurrent migraine headache, found that all the subjects had elevated beta activity in the parietal, central, and frontal regions of the brain. This paper is limited, as the mechanism of injury and the length of time the subjects had the headache was not recorded. It appears that the exact nature of changes in QEEG patterns following a closed head injury is in need of more research, but QEEG holds promise for helping to direct headache treatments.

Trigger Points/SEMG

Trigger points in the neck and head can contribute to migraine headache by referring pain into other areas of the head, either around the trigger point, or at some distance away from it (Travell & Simons, 1993). The most common muscles which produce a headache pattern are: (a) the sternocleidomastoids, (b) upper trapezius, (c) cervical paraspinals, and (d) facial muscles, including the masseter and temporalis muscles (Travell & Simons, 1993). Often, headaches that are diagnosed as migraines are actually referred pain patterns from the sternocleidomastoids and upper trapezius (Travell & Simons, 1993).

Trigger points may be caused by: (a) trauma, (b) chilling (i.e., over-cooling muscle), (c) muscle overload, and (d) overwork fatigue (Travell & Simons, 1993). Trigger points form in muscles as a local contraction in a small number of muscle fibers in a larger muscle or muscle bundle. The muscle bundle then pulls on tendons and ligaments associated with the muscle, causing muscle weakness and pain deep within a joint where there are no muscles. Referred pain patterns in muscles have been found in both tension type headache and migraine, following head injury, and have been mapped to trigger points in the posterior cervical, head, and shoulder muscles (Fernández-de-las-Peñas et al., 2007).

Trigger points are diagnosed by examining signs, symptoms, pain patterns, and manual palpation, as outlined in Travell and Simons (1993). However one review of nine studies questioned the reliability of physical examination for diagnosing trigger points (Lucas et al., 2009). Despite this criticism, palpation remains the method of choice for most practitioners.

Donaldson et al. (1994) demonstrated an 80% reliability/accuracy when diagnosing trigger point activity using surface electromyographic (SEMG) assessment procedures. Examining the activity of the sternocleidomastoids, upper trapezius, cervical paraspinals, lower trapezius, and scalenes the author found that muscles with trigger points had a 20% or greater peak amplitude compared to their homologous partners. A combination of a manual trigger point evaluation and a SEMG evaluation may lead to greater accuracy in diagnosing trigger point activity that may be causing or contributing to headache symptoms.

Stress

Stress is another factor to consider when assessing chronic pain problems in general, and headache in particular. Selye (1956) defined stress as "the non-specific response of the body to any demand placed upon it" (p. 55). Today stress is understood as the cumulative *allostatic load* in a physiological system, or the "wear and tear" on a body, which develops when an individual struggles to adapt to life changes (McEwen, 2002; 2004).

Most of the common physical symptoms of stress are caused by our own bodies' "fight or flight" response system, preparing us to either to stay and fight or run away from a perceived threat. This fight or flight response produces chemicals and hormones to heighten awareness and give a boost of energy and strength. If a fight or flight state persists for a long period of time, existing major health problems can be exacerbated, and new major health problems can be created (Benarroch, 2007). Headache may be affected by stress-related vascular changes, psychological factors, or muscle tension. Research, in trying to tease out the efficacy of specific biofeedback treatment techniques for headache, such as temperature training or skin conductance training, has been disappointing. It is difficult to establish separate and distinct treatment effects for each of the treatments, as they are so interrelated (e.g., increasing temperature in the hands usually results in decreased galvanic skin response and increased muscle relaxation) (Yucha & Montgomery, 2008).

In summary, headache can have numerous etiological factors contributing to the onset and maintenance of the pain. A comprehensive evaluation is needed to assess which factors are contributing to the pain, so that a detailed treatment plan can be developed.

Case Study

The subject was a 56-year-old female with a 30-year history of headache, diagnosed as migraines. The onset of headache was not clearly defined, but appeared to begin at about age 12. At age 26 she was involved in a series of three motor vehicle accidents, one of which was quite severe. She remembered being hit from behind at high speed, with her head fully rotated to the left watching oncoming traffic. There was no loss of consciousness, but she reported being quite dazed from striking the left side of her head in the frontal/temporal areas.

The intensity of the headache dramatically increased after the third accident. Headache immediately became an almost daily occurrence, incapacitating her and creating a loss of function at work. She was a senior executive in a major worldwide organization, so the loss of productivity was a great concern for her. The headache occurred over her entire head, but predominantly in the temporal areas and bilaterally behind the eyes. She reported associated symptoms of balance problems, ringing in the ears, and severe sensitivity to light and noise.

At the time of the initial contact, she reported no other history of trauma and no other head injuries. She did not smoke or drink alcohol. She drank two to three cups of coffee a day. Medically she reported minor sinus problems and low back pain. Several years previously, she had been diagnosed with chronic fatigue syndrome, which required her to take two years off of work. Presently she was taking Elavil, 25 mgs daily, and Maxalt, both for management of headache pain. Over the years she reported trying most antiheadache medications with little or no results, though she experienced a variety of negative side effects.

Assessment

The subject was evaluated using multiple assessment procedures. A quantitative electroencephalogram (QEEG) was used to evaluate the possibility of a closed head injury. A routine trigger point and surface electromyogram (SEMG) evaluation was completed to identify possible muscular involvement, and a routine psychophysiological stress profile was completed to assess the possible contribution of stress factors in her headache symptoms.

Closed Head Injury

QEEG

The EEG was recorded with Brainmaster Discovery™ Software version 1.5.9 and the Discovery 24E™ amplifier (www.brainmaster.com). The EEG was recorded at a sampling rate of 256 Hz at 19 sites (International 10/20 system) using an electrode cap (Electrocap International, Inc.) and a linked ears montage. Impedance at each site was measured and reduced to below 5K ohms. Recordings were 10 minutes in length in both an “eyes closed” and “eyes open” condition. The data was then processed by a qualified technician using the Neuroguide™ (www.appliedneuroscience.com) software program (NeuroGuide, v2.6.1), and artifacts were visually removed from the EEG data. An edited sample of 2:38 minutes was used and the reliability of this data was >95% based on the split-half reliability test. Finally, a spectral analysis of the data was performed and compared to the Neuroguide normative database.

Trigger Points

Assessment consisted of a thorough manual trigger point examination of the head, neck, and torso, as outlined in Travell and Simons (1993). The particular muscles examined included: (a) temporalis, (b) masseters, (c) sternocleidomastoids, (d) upper trapezius, (e) splenius capitis, (f) mid trapezius, (g) rhomboids, (h) levator scapulae, (i) lower trapezius, and (j) scalenes. Any muscles below the base of the shoulder blades were not examined for trigger points.

An SEMG assessment was then performed using the Thought Technology Biograph Infiniti™ software Version 3.0 and the ProComp Infiniti™ 8 channel encoder (www.thoughttechnology.com), following the protocol as outlined by Donaldson et al. (1994). The muscles assessed included: (a) sternocleidomastoids, (b) cervical paraspinals, (c) upper trapezius, (d) lower trapezius, and (e) scalenes. Electrodes (Triodes™) were placed over the belly of the muscles on both the left and right sides of the body. The individual was asked to perform a series of specific movement(s), primary to each muscle’s functional purpose, repeating each movement five times. Data were captured at a sampling rate of 256 samples/second with a band pass filter of 20–500 Hz, and a notch filter at 60 Hz. Artifacts were identified with a visual inspection and were eliminated from the data file. The peak amplitude for each movement was then selected and compared to the peak amplitude of the homologous partner. The difference between the two peak amplitudes was calculated, with the difference then divided by the higher peak amplitude to produce a percentage difference.

Stress

Assessment followed the psychophysiological stress profile protocol included in Vietta (Sue) Wilson's *Optimizing Performance and Health* software suite (Beta Version 2007; see Wilson, 2008 and Wilson & Somers, 2011, for details). This suite was coupled with the Thought Technology Biograph Infiniti™ software Version 3.0 (www.thoughttechnology.com). EEG data was recorded at the CZ site of the International 10–20 System of Electrode Placement with a linked ears montage. Muscle tension in the forehead was measured with an SEMG headband. Muscle tension in the upper trapezius of the nondominant side was recorded with a Triode™ placed along the belly of the muscle. Respiration was recorded by placing a respiration sensor around the abdomen. Blood volume pulse, heart rate, and heart rate variability were recorded by attaching a blood volume pulse detection sensor on the pad of the thumb of the nondominant hand. Finger temperature was recorded by attaching a temperature sensor to the pad of the middle finger of the nondominant hand, being careful not to restrict the circulation to the end of the finger. The galvanic skin response was measured with two palmar sensors attached to the pads of the palm of the nondominant hand.

The psychophysiological stress profile protocol allows for 16 samples of an individual's performance during differing periods of time. The test starts with: (a) baseline, sitting with eyes open, (b) baseline, sitting eyes closed, (c) Stroop test, (d) recovery, (e) math stressor, (f) recovery, (g) game, (h) recovery, (i) positive image, (j) recovery, (k) mouse walk, (l) recovery, (m) anticipation, (n) brief mental stressor, (o) recovery, and (p) biofeedback-assisted relaxation.

Assessment Results

QEEG

The results of the QEEG showed generalized decreased (1–2 SDs) electrical activity as measured in *Z*-scores across the entire frequency spectrum, except for High Beta. High Beta showed no variance from zero throughout most of the brain. Decreased coherence was noted at F7, F4, and T4. Increased phase lag was evident in the Beta and High Beta frequencies, primarily affecting F8, F4, T4, P4, PZ, and O1. The subject's probability of membership in the mild traumatic brain injury population was 97.5%, with a severity rating of 2.33 (out of 10). Sites particularly affected were T4 (Alpha, –2.03) and T3–T4 (Theta, 2.09).

Trigger Points/SEMG

The results of the trigger point examination for the neck and shoulders showed the presence of 7 trigger points distributed in the following muscles: (a) left temporalis, (b) left masseter, (c) right sternocleidomastoids, (d) left splenius capitis, (e) right upper trapezius, (f) right rhomboids, and (g) left levator scapulae. With the exception of the rhomboids, all noted trigger points referred pain into the head.

The results of the SEMG evaluation showed the presence of muscle imbalances particularly affecting the sternocleidomastoids, lower trapezius, scalene, and cervical paraspinals. The readings for each muscle are listed in the Table.

The results of the stress assessment are depicted in the Figure. As can be seen:

a. Heart rate increased slightly during the stressors, but recovered during recovery.
b. Heart rate variability showed appropriate increases and decreases during the test.
c. Respiration rate initially went up during relaxation phases, but gradually came down over time, with her overall breathing rate substantially slower at the end.
d. Blood volume was generally stable except for a marked increase during the second stressor.
e. Skin conductance increased, particularly during the game and during the mouse walk.
f. Temperature was low throughout.
g. SEMG activity in the face showed increased activity during the Stroop test, positive image, and biofeedback.
h. SEMG activity in the trapezius was generally elevated and substantially increased during the positive imagery and recovery from same.
i. The EEG report showed elevated Theta activity with a "busy brain."

During debriefing with the subject, she reported that she was overly critical of herself, overanalyzing her performance on the evaluations, and belittling herself when she made a mistake. She was aware of her hands getting colder and palms sweatier, but unaware of the tension in her face

Table. Bilateral SEMG amplitudes during initial assessment			
		Maximum Amplitudes	
Muscle	Movement	Left (μV)	Right (μV)
SCM	Neck flexion	59.62	168.44
SCM	Left rotation	20.40	256.04
SCM	Right rotation	92.78	19.58
CPS	Neck flexion	17.36	14.57
CPS	Left rotation	107.74	15.21
CPS	Right rotation	50.58	43.19
UTP	Arm abduction	64.31	43.98
LTP	Scapular retraction	948.17	536.24
Scalenes	Deep breath	95.99	159.24

and shoulders. She had no idea why there was an increase in tension when she tried to relax, as she visualized herself horseback riding, which was her favorite hobby and preferred form of stress release.

Treatment

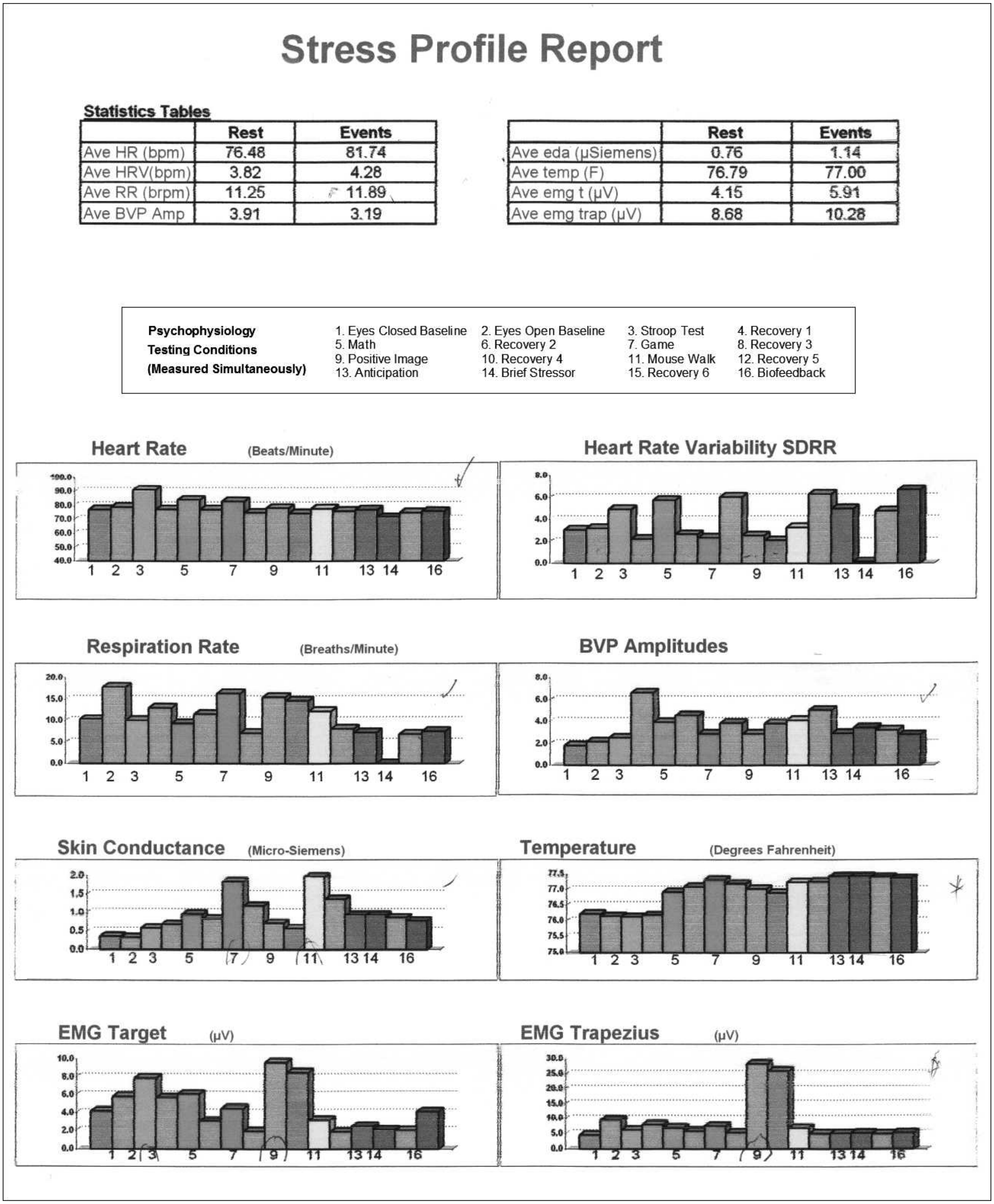
Based upon the above results, a multifaceted treatment program was designed. In the view of the lead author, the trigger point activity, the muscle imbalances, and her stress (skin conductance, temperature, and muscle activity) were the most critical factors. The trigger point referred pain patterns (as outlined in Travell & Simons, 1993) matched the reported pain, plus the muscles in the face and upper trapezius showed elevated activity in response to stress. Conversely, it was not certain if the QEEG results indicated a contribution of brain injury to the reported pain, as the QEEG results did not show a coup contrecoup pattern (i.e., injuries on opposite sides of the brain due to forces in opposite directions) in either phase lag or coherence, nor did the absolute power show any significant localized elevations or decreases of power. This was confirmed reviewing the FFT Absolute Power using the Laplacian montage (this montage uses relative measures to detect localized abnormalities that may be less obvious due to medication effects). Therefore, neurofeedback was not included in her treatment.

Given the presence of the trigger points in the sternocleidomastoids and cervical paraspinals it was decided to immediately institute a massage therapy program to provide some symptomatic relief. As the massage therapy (muscle release work) was initiated, a program of neuromuscular rehabilitation was started for the purpose of balancing the affected muscles, utilizing reciprocal inhibition within the musculoskeletal system (Donaldson et al., 1998).

After two weeks, the subject reported a decrease in the frequency and severity of headache. Treatment of the neck muscle imbalances using SEMG up-training techniques continued, as did an aggressive myofascial massage program.

In addition, a stress management program focusing on relaxing visualizations and diaphragmatic breathing, was conducted. The client was instructed in the use of the Stress Eraser™ (www.stresseraser.com) to be utilized at home. During one visualization session, a pattern of increased stress occurred (GSR increasing). When discussing this with the subject, she noted that in her visualizations she was riding her favorite horse, a gray gelding. She was asked to visualize riding another horse, and she chose a brown mare. The GSR readings reversed almost instantly, moving towards a more relaxed state. When debriefing her, she stated that although the grey gelding was her favorite, it was so because it was difficult to handle and had thrown her a few times. She realized that she was tensing up during visualization of the grey gelding. A simple switch of horses in her visualization proved to enhance her recovery.

After using her stress reduction techniques for four weeks, the subject was able to reduce the tension in her upper trapezius from 23 μV to 4 μV in three minutes. Within six weeks of starting treatment, she reported a significant decrease in headache when utilizing the breathing techniques while riding and driving, and when utilizing the visualization techniques while working at the computer.



Stress Profile Report

Statistics Tables

	Rest	Events
Ave HR (bpm)	76.48	81.74
Ave HRV(bpm)	3.82	4.28
Ave RR (brpm)	11.25	11.89
Ave BVP Amp	3.91	3.19

	Rest	Events
Ave eda (µSiemens)	0.76	1.14
Ave temp (F)	76.79	77.00
Ave emg t (µV)	4.15	5.91
Ave emg trap (µV)	8.68	10.28

Psychophysiology Testing Conditions (Measured Simultaneously)			
1. Eyes Closed Baseline	2. Eyes Open Baseline	3. Stroop Test	4. Recovery 1
5. Math	6. Recovery 2	7. Game	8. Recovery 3
9. Positive Image	10. Recovery 4	11. Mouse Walk	12. Recovery 5
13. Anticipation	14. Brief Stressor	15. Recovery 6	16. Biofeedback

Figure. Psychophysiological stress profile report.

SEMG treatment of the muscle imbalances was discontinued at week eight, as the muscles in the neck, shoulders and midback were all balanced.

After six weeks, the headache frequency reduced to once per week, and the intensity reduced to 3 out of 10 pain level. Performance at work and at play also dramatically improved.

After this time period the subject decided to seek further treatment for low back pain. Currently she is seen occasionally for relaxation massage. Her headaches are virtually nonexistent, and she estimates that her productivity at work has increased by 25%.

Conclusion

Traditionally, headache has been classified as migraine, tension, mixed, or cause unknown. Peripheral biofeedback modalities, such as hand temperature and galvanic skin response have been recommended for the treatment of migraines, and SEMG has been recommended for the treatment of tension headache (Merletti & Parker, 2004). Because it is often difficult to clearly distinguish between headache types in individual patients, this dichotomous biofeedback treatment strategy has created some confusion, and has lead to inconsistent treatment results (Yucha & Montgomery, 2008).

Further complicating the issues today is the development of EEG neurofeedback techniques. These techniques allow for the assessment and treatment of brain injuries, which were previously often undiagnosed, and may be helpful for treatment of headache but further research is needed to demonstrate treatment efficacy. Biofeedback practitioners, with their multitude of different assessment and treatment techniques, occupy a rather unique position in their ability to assess complex and difficult cases. Such is the case study presented here.

The subject's history of low-grade headache since the onset of puberty is suggestive of a vascular/menstrual component characteristic of migraines. The history of motor vehicle accidents is suggestive of whiplash and brain injury. The significant increase in frequency and intensity suggests a complex interaction between the vascular and muscular components in her headache pattern, with brain injury as a possible contributing factor.

The ability to tease out the relative contribution of vascular, muscular, and stress factors lead to a rapid and successful outcome in the treatment of this complex case. As the insurance industry and policy makers move towards evidence-based medicine, the development of comprehensive assessment and treatment protocols, with increased treatment efficacy, serves to meet this need. With the wide range of objective biofeedback and neurofeedback tools that are available, biofeedback practitioners have the ability to move to the forefront of evidence-based treatments. It is incumbent on biofeedback clinicians to learn a variety of assessment and treatment tools and to integrate them effectively to achieve the greatest treatment success. Remember, when all one has is a hammer, then everything looks like a nail.

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