

Neurofeedback in fibromyalgia syndrome

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ÖZET

Fibromyalji sendromunda nörofeedback

EEGbiofeedback (Nörofeedback-NFB), kişilerin beyin dalgalarını değiştirebilmelerini sağlayan bir öğrenme stratejisidir. Bu olgu sunumunda, Fibromyalji Sendromu (FMS) bulunan üç hastaya NFB protokolü uyguladık. Vizüel Analog Skala ile ağrı değerlendirmesi, yorgunluk, Hamilton Depresyon ve Anksiyete Çizelgesi Ölçeği, Beck Depresyon ve Anksiyete Çizelgesi Ölçeği ve SF-36 kayıtları, NFB uygulaması öncesinde ve sonrasında değerlendirildi. On seans sonunda semptomların çoğu azaldı. Ölçeklerin tümünde tedavi sonrası ilerleme kaydedildi. Bu çalışmanın sonuçları, NFB uygulamasına FMS tedavisinde yeni bir metot olabileceğini düşündürmektedir.

Anahtar kelimeler: Nörofeedback, Fibromyalji Sendromu, ağrı

SUMMARY

EEG Biofeedback (Neurofeedback-NFB) is a learning strategy that enables people to alter their brainwaves. In the present case study, we applied a NFB protocol on three patients with Fibromyalgia Syndrome (FMS). The existing symptoms and clinical conditions of the patients attributed to FMS, Visual Analog Scale for pain and fatigue, Hamilton Depression and Anxiety Inventory Scales, Beck Depression and Anxiety Inventory Scales, and SF-36 were recorded before and after NFB training. Most of the symptoms were decreased after ten sessions. There was also improvement in all of the scales after the treatment. The results of the present study may suggest NFB training as a novel treatment method in FMS.

Key words: Neurofeedback, Fibromyalgia Syndrome, pain

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Introduction

Electroencephalographic (EEG) biofeedback is an operant conditioning procedure that supports the individual's ability to modify the amplitude, frequency or coherency of the neurophysiologic dynamics of the brain (Egner and Gruzelier 2004). Therapeutic application of EEG biofeedback is often referred to as "Neurofeedback (NFB)" (Vernon et al. 2003, Lubar 1997). NFB has various clinical applications such as epilepsy, attention deficit hyperactivity disorder, alcohol abuse and post traumatic stress disorder. Sensorimotor rhythm (SMR) training is one of the most commonly applied NFB protocol (Egner et al. 2004). SMR is normally associated with a quiet body and active mind. It is often depressed in anxiety, panic, chronic pain, migraine, attention deficit disorders, mood disorders, and other stress related disorders (Laibow 1999).

SMR activity is thought to be generated through thalamocortical interactions during burst firing activity in ventrobasal thalamic relay nuclei associated with the suppression of somatosensory afferent gating (Howe 1972). SMR training appears to facilitate thalamic inhibitory mechanisms. On the other hand, the trained enhancement of SMR activity has cognitive implications such as reducing impulsiveness/hyperactivity, enhancing attention processing and semantic memory performance (Serman 1996).

Fibromyalgia syndrome (FMS) is a disorder of uncertain etiology characterized by widespread musculoskeletal pain, increased tenderness in multiple points, and several symptoms including fatigue, sleep disturbances, morning stiffness, headache, depression, irritable colon disease and female urethral syndrome. FMS patients frequently complain of deficits in memory and attention. Neuropsychological tests have revealed poor working and long term memory, vocabulary deficits and lower information processing speed. In FMS perceptual amplification of pain, and neurosensitization are observed, both of which might be related to disinhibitory mechanisms (Alanoglu et al. 2005, Ozgocmen et al. 2002 and 2003, Howe 1972) demonstrated reduced P300 amplitudes in patients with FMS. P300 has been proposed to reflect the activation of inhibitory processes, the amplitude of P300 reflects central nervous system (CNS) inhibition; the larger the amplitude, the more the inhibition (Tomberg and Desmedt, 1998). SMR training increases P300 amplitudes which support the fact that SMR training facilitates

thalamocortical inhibitory mechanisms (Egner and Gruzelier 2001).

When taking into consideration this background knowledge we hypothesized that NFB training aiming to enhance the SMR activity might be a useful therapeutic application in FMS patients. In this preliminary study, SMR training was used to alleviate the clinical symptoms of 3 FMS patients aiming to put forward a new adjunctive therapeutic approach to FMS treatment.

Case Report

Three patients applied to Outpatient Clinic of Physical Medicine and Rehabilitation Department of Kocaeli University who were diagnosed as FMS according to the criteria of American College of Rheumatology (Wolfe et al. 1990). All the patients reported that they did not receive any medication or other treatments for their complaints regarding FMS but only simple analgesics. SMR training was performed by Alien Technik 3/32 setup and BrainFeedback-3 EEG biofeedback software to all of the patients. EEG was recorded from C4 (according to standard 10-20 system) with 46 Hz band with and the reference electrode placed on left, and the ground electrode on the right earlobe. Signal was acquired at 256 Hz, A/D converted and band-filtered to extract delta (1-4 Hz), theta (4-7 Hz), alpha (8-12 Hz), SMR (12-15 Hz), the beta1 (15-20 Hz), and "high beta" (22-30 Hz) components. Impedance was kept below 5 KW, and artifact-rejection thresholds were set separately for each patient to interrupt EEG fluctuations caused by eye and body movements. Band amplitude values were transformed online into visual feedback representations. The patients were informed about the feedback system and instructed to follow the continuous feedback process and try to maximize their scores. Whenever the patients enhanced SMR activity, and decreased theta activity relative to pre-feedback baseline measures, rewards (points and auditory beeps) were gained and so their scores were increased. The treatment sessions were 30 minutes and the patients were trained 3 sessions per week. The mean amplitudes of SMR, theta, and theta/SMR ratios were recorded at baseline and after treatment.

The signs and symptoms of FMS which are pain, morning stiffness, subjective paresthesia, sleep disorder, anxiety, headache, dysmenorrhea, irritable colon disease, depression, female urethral syndrome and chronic fatigue were questioned.

They were noted as present or absent before the treatment; and as present, absent or decreased after the treatment. Patients were also evaluated by the following scales: A separate 10-cm visual analog scale (VAS) for fatigue and pain, Hamilton Depression Inventory Scale (HDS), Hamilton Anxiety Inventory Scale (HAS), Beck Depression Inventory Scale (BDS), Beck Anxiety Inventory Scale (BAS), and Short Form 36 (SF-36). Subscales of SF-36 are physical functioning, social functioning, physical role, emotional role, mental health, vitality, bodily pain, and general health. SF-36 was used to evaluate the impact of NFB on patients' quality of life, with higher scores indicating better quality of life.

Case 1: BC was a 33 years old woman working in a university as a secretary. She had widespread musculoskeletal pain, morning stiffness, sleep disorders, anxiety, headache, dysmenorrhea, irritable

colon disease, depression, paresthesia in hands, and chronic fatigue for 2 years.

Case 2: IT was a 32 years old woman working as an employee in a bank. Her complaints including widespread musculoskeletal pain, morning stiffness, anxiety, subjective paresthesia, female urethral syndrome, irritable colon disease, depression, paresthesia in hands and chronic fatigue started 4 years ago.

Case 3: CS was 31 years old woman working in a university as an employee. She had the symptoms of FMS including widespread musculoskeletal pain, morning stiffness, sleep disorders, anxiety, female urethral syndrome, headache, dysmenorrhea, depression, paresthesia in hands and chronic fatigue for 6 months.

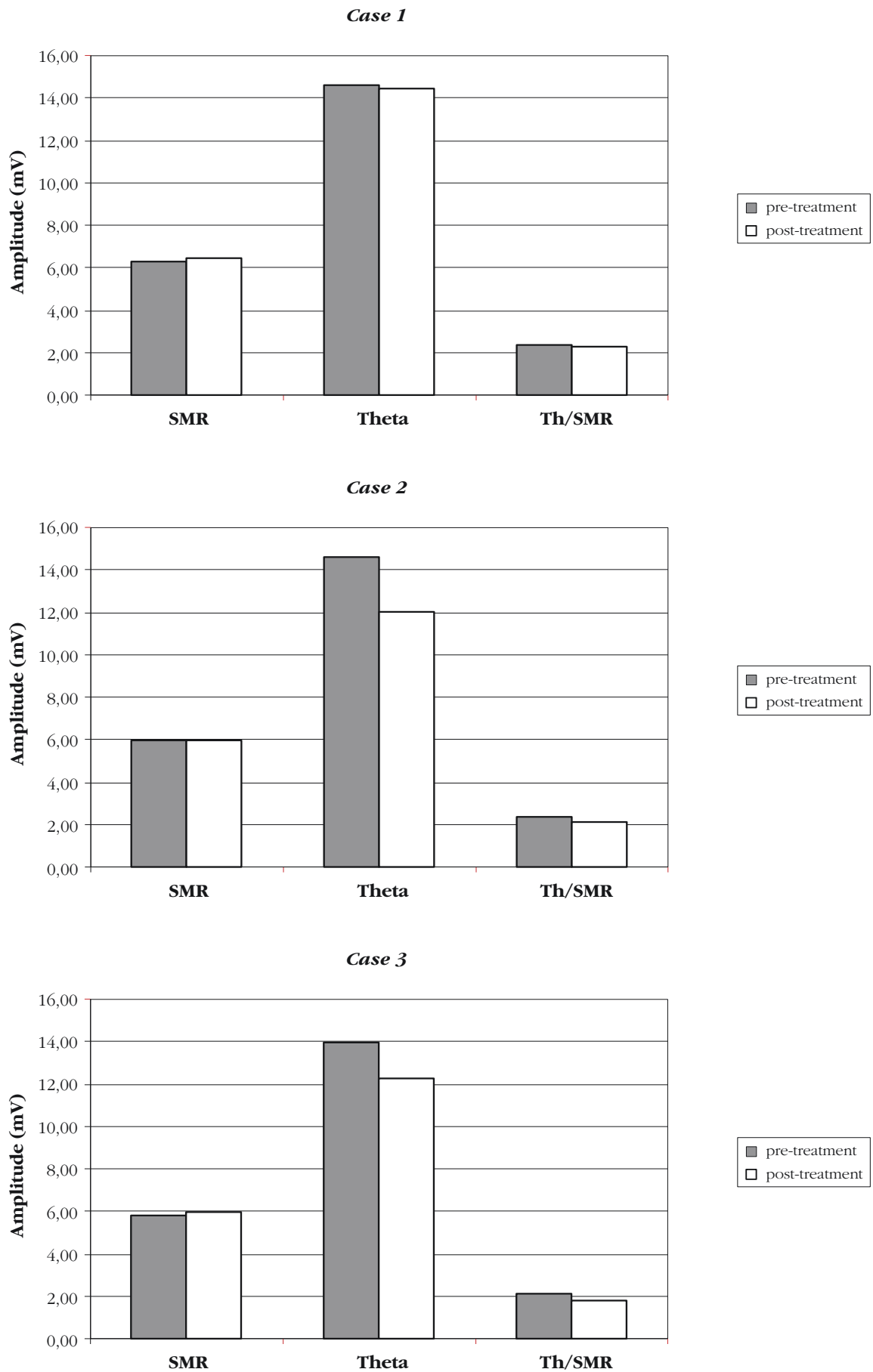
Ten sessions of SMR training were performed to each patient. Baseline and post-treatment values

Figure 1: Pre-treatment and post-treatment values of visual analog scale (VAS) for fatigue and pain, Hamilton Depression Inventory Scale (HDS), Hamilton Anxiety Inventory Scale (HAS), Beck Depression Inventory Scale (BDS), Beck Anxiety Inventory Scale (BAS), and short form 36 (SF-36). Subscales of SF-36 are physical functioning.

ASSESSMENT SCALE	BC		IT		CS	
	Pre-T*	Post-T [‡]	Pre-T	Post-T	Pre-T	Post-T
VAS (PAIN)	8.00	4.00	8.00	3.50	5.00	2.00
VAS (FATIGUE)	9.00	5.00	8.00	5.00	4.00	1.50
HDS	21.00	6.00	17.00	3.00	5.00	3.00
HAS	38.00	14.00	35.00	3.00	14.00	4.00
BDS	21.00	4.00	9.00	1.00	1.00	1.00
BAS	43.00	15.00	8.00	1.00	4.00	4.00
SF-36						
Physical functioning	44.40	72.20	61.10	77.70	88.88	88.88
Role Limitations	25	50	0	100	100	100
Bodily Pain	22.50	67.50	57.50	67.50	90	90
Social Functioning	25	62.50	87.50	75	100	62.50
General Mental Health	24	72	68	84	68	76
Role Limitations due to Emotional Problems	0	66.66	100	100	100	66.66
Vitality, Energy or Fatigue	15	60	60	70	70	70
Health Compared to Last Year	25	75	75	100	75	75

* Pre-T= Pre-treatment
[‡] Post-T= Post-treatment

Figure 2: Changes in SMR and theta values, and theta/SMR ratios of the patients during NFB treatment.



of VAS, HDS, HAS, BDS and BAS of each patient are shown in figure 1, and amplitudes of SMR and theta, and theta/SMR ratios are shown in figure 2. The symptoms related with FMS were diminished in most aspects in all of the patients after the treatment. Widespread musculoskeletal pain, morning stiffness, sleep disorders, headache, irritable colon disease, and chronic fatigue were resolved in patient 1; widespread musculoskeletal pain, subjective paresthesia and female urethral syndrome in patient 2; and widespread musculoskeletal pain, morning stiffness, sleep disorders, female urethral syndrome, headache and paresthesia in hands in patient 3. VAS scores of pain and fatigue decreased; the depression and anxiety scales also revealed a prominent progression after SMR training in all patients. An improvement in all subscales of SF-36 was observed in patients 1 and 2. Regarding EEG recordings, in all patients a tendency to increase and a tendency to decrease were observed in SMR and theta/SMR values, respectively.

Discussion

In this preliminary study, leaning on the theoretical basis of facilitator effect on thalamic inhibitory mechanisms of the SMR training, a new therapeutic approach was applied to 3 FMS patients. Ten sessions of SMR training resulted in improvement in the clinical symptoms of all patients and compromising results were obtained.

In the current literature researchers have examined the effects of NFB in treating a wide range of psychiatric and other medical disorders including seizure disorders, attention deficit disorder (ADD), attention deficit hyperactivity disorder (ADHD), alcohol abuse, post traumatic stress disorder, mood disorders, anxiety disorders, learning disabilities, and chronic pain disorders (Kop et al. 2005, Monastra 2003, Monastra et al. 2002, Laibow, 1999). In these various diseases, there may be abnormal EEG frequency spectrum, and NFB may facilitate modulation of excitation levels in thalamocortical system by modifying the amplitude, frequency or coherency of the neurophysiologic dynamics of the brain. From the apparent impact of SMR training on sensorimotor excitation, Lubar and colleagues have extrapolated the application of SMR training to the treatment of hyperactivity disorder (Shouse and Lubar 1979, Lubar and Shouse 1976). In his 10 years follow-up study, he reported that 80% of ADD and ADHD patients had improved by NFB (Lubar et al. 1995).

The P300 component of cognitive event related potentials (ERPs) is a positive potential reaching its maximum peak at the parietal site in about 300-700 ms after a stimulus. The P300 has been proposed to reflect attentional allocation and context updating processes of working memory (Polich and Herbst 2000), and the activation of inhibitory processes. The amplitude of P300 reflects central nervous system (CNS) inhibition; the larger the amplitude, the more the inhibition (Tomberg and Desmedt 1998), while its time of occurrence (latency) reflects mental processing speed (Polich and Herbst 2000); the earlier the latency, the easier the processing. The finding of reduced amplitude and prolonged latency of P300 might suggest decreased inhibitory processes and/or depression. SMR training increases P300 amplitudes which support the fact that SMR training facilitates thalamocortical inhibitory mechanisms (Egner and Gruzelier 2001).

Chronic pain states have been associated with reduced thalamic blood flow, whereas acute pain increases thalamic blood flow (Mountz et al. 1995a). The reason for this difference is postulated to be an increasing disinhibition of the medial thalamus with chronic pain Mountz et al. (1995b) reported that FMS patients had a decreased thalamic and caudate blood flow compared to healthy controls on single-photon-emission-computed tomography imaging. Studies of ERPs may also show the disinhibition of CNS physiology in various diseases. It was reported that P300 amplitudes were reduced in clinical conditions like schizophrenia, alcoholism, ADHD, Parkinson's disease, and Alzheimer disease (Ozdogan et al. 2004, Pokryszko-Dragan et al. 2003, Van Der Stelt et al. 1998, Lagopoulos et al. 1998, Roth and Cannon 1972). Ozgocmen et al. (2002 and 2003), and Alanoglu et al. (2005) demonstrated reduced P300 amplitudes in patients with FMS, and sertraline was shown to increase the amplitude of P300 within eight weeks (Ozgocmen et al. 2003). Thus, we can put forward an idea that some benefits may be obtained by the treatment modalities altering P300 like SMR training.

The current treatment methods including medications, exercise, physical and occupational therapies, biofeedback, cognitive-behavioral therapies for FMS rarely lead to long term relief. Practitioners often combine treatments to get the best result and this is often convenient. Psychological and psychophysiological factors play a large role in FMS, and these factors influence central nervous system processes involved

in the pathophysiology of FMS (Monastra, 2003). So the interventions like EMG biofeedback, relaxation therapies, cognitive-behavioral therapies, and NFB can have effect not only on the attitudes and beliefs about symptoms and functioning of the patients, but also on physiology and pain. Besides, possible facilitator effect on thalamic inhibitory mechanisms of SMR training also helped us to predict that NFB can be a useful candidate for FMS treatment. Mueller et al. (2001) followed thirty FMS patients prospectively through a brainwave-based intervention known as electroencephalograph-driven stimulation (EDS). These patients, experienced significant reductions in FMS symptoms; important improvements were obtained not only in pain intensity but also in cognitive processing difficulties, mood, sleep, and fatigue. Regarding the wavebands, the mean amplitudes of delta, theta and alpha were significantly reduced after the treatment.

In our study, after performing 10 sessions of NFB treatment, most of the symptoms of the patients were decreased, and certain progressions in HDS, HAS, BDS, BAS, SF-36 and VAS were obtained in three of the patients. On the other hand, when we evaluate the wavebands, we found a tendency of rising in SMR values, and a tendency of reducing in theta values.

Although it is impossible to make definite conclusion from these three cases, the clinical improvements suggest that NFB might be a novel and an adjunct treatment modality in FMS. Also when considering the inhibitory effects of SMR training, central disinhibitory mechanism might have an important part in the pathophysiology of FMS. Thus, it seems worth to perform further controlled clinical trials with large samples and long-term follow ups regarding NFB in FMS patients.

References

Alanoglu E, Ulas UH, Ozdag F, Odabasi Z, Cakci A, Vural O: Auditory event-related brain potentials in fibromyalgia syndrome. *Rheumatol Int.* 2005; 25(5): 345-9.

Egner T, Gruzelier JH: EEG biofeedback of low beta band components: frequency-specific effects on variables of attention and event-related brain potentials. *Clin Neurophysiol* 2004; 115(1): 131-139

Egner T, Gruzelier JH: Learned self-regulation of EEG frequency components affects attention and event-related brain potentials in humans. *Neuroreport* 2001; 12: 4155-60

Egner T, Zech TF, Gruzelier JH: The effects of neurofeedback training on the spectral topography of the electroencephalogram. *Clin Neurophysiol* 2004; 115: 2452-2460

Howe RC, Sterman MB: Cortical-subcortical EEG correlates of suppressed motor behavior during sleep and waking in the cat. *Electroencephalogr Clin Neurophysiol* 1972; 32(6): 681-695

Iadarola MJ, Max MB, Berman KF, Byas-Smith MG, Coghill RC, Gracely RH et al: Unilateral decrease in thalamic activity observed with positron emission tomography in patients with chronic neuropathic pain. *Pain* 1995; 63(1): 55-64

Kop WJ, Lyden A, Berlin AA, Ambrose K, Olsen C, Gracely RH et al: Ambulatory monitoring of physical activity and symptoms in fibromyalgia and chronic fatigue syndrome. *Arthritis Rheum* 2005; 52(1): 296-303

Lagopoulos J, Gordon E, Barhamali H, Lim CL, Li WM, Clouston P et al: Dysfunctions of automatic (P300a) and controlled (P300b) processing in Parkinson's disease. *Neurol Res* 1998; 20: 5-10

Laihow R: Medical applications of neurobiofeedback. In: Evans JR, Abarbanel A, editors. *Quantitative EEG and neurofeedback*. California: Academic Press 1999. p 93-101

Lubar JF, Shouse MN: EEG and behavioral changes in a hyperkinetic child concurrent with training of the sensorimotor rhythm (SMR): a preliminary report. *Biofeedback Self Regul* 1976; 1(3): 293-306

Lubar JF, Swartwood MO, Swartwood JN, O'Donnell PH: Evaluation of the effectiveness of EEG neurofeedback training for ADHD in a clinical setting as measured by changes in T.O.V.A. scores, behavioral ratings, and WISC-R performance. *Biofeedback Self Regul* 1995; 20(1):83-99

Lubar JF: Neocortical dynamics: implications for understanding the role of neurofeedback and related techniques for the enhancement of attention. *Appl Psychophysiol Biofeedback* 1997; 22(2): 111-126

Monastra VJ, Monastra DM, George S: The effects of stimulant therapy, EEG biofeedback, and parenting style on the primary symptoms of attention-deficit/hyperactivity disorder. *Appl Psychophysiol Biofeedback* 2002; 27(4): 231-49

Monastra VJ: Clinical applications of electroencephalographic biofeedback. In: Schwartz MS, Andrasik F, editors. *Biofeedback; A practitioner's guide*. 3rd Edition. NewYork: Guilford Press 2003. p 438-463

Mountz JM, Bradley LA, Modell JG, Alexander RW, Triana-Alexander M, Aaron LA et al. Fibromyalgia in women. Abnormalities of regional cerebral blood flow in the thalamus and the caudate nucleus are associated with low pain threshold levels. *Arthritis Rheum* 1995; 38(7): 926-938

Mueller HH, Donaldson CC, Nelson DV, Layman M: Treatment of fibromyalgia incorporating EEG-Driven stimulation: a clinical outcomes study. *J Clin Psychol* 2001; 57(7): 933-952

Ozdog MF, Yorbik O, Ulas UH, Hamamcioglu K, Vural O: Effect of methylphenidate on auditory event related potential in boys with attention deficit hyperactivity disorder. *Int J Pediatr Otorhinolaryngol* 2004; 68(10): 1267-1272

Ozdogmen S, Cimen OB, Ardicoglu O: Relationship between chest expansion and respiratory muscle strength in patients with primary fibromyalgia. *Clin Rheumatol* 2002; 21: 19-22

Ozdogmen S, Yoldas T, Kamanli A, Yildizhan H, Yigiter R, Ardicoglu O: Auditory P300 event related potentials and serotonin reuptake inhibitor treatment in patients with fibromyalgia. *Ann Rheum Dis* 2003; 62: 551-555

Pokryszko-Dragan A, Slotwinski K, Podemski R (2000): Modality-specific changes in P300 parameters in patients with dementia of the Alzheimer type. *Med Sci Monit* 2003; 9: 130-134

Polich J, Herbst KL: P300 as a clinical assay: rationale, evaluation, and findings. *Int J Psychophysiol* 2000; 38(1): 3-19

- Roth WT, Cannon EH: Some features of the auditory evoked response in schizophrenics. *Arch. Gen. Psychiatry* 1972; 27: 466-471
- Shouse MN, Lubar JF: Operant conditioning of EEG rhythms and ritalin in the treatment of hyperkinesis. *Biofeedback Self Regul* 1979; 4(4): 299-312
- Sterman MB: Physiological origins and functional correlates of EEG rhythmic activities: implications for self-regulation. *Biofeedback Self Regul* 1996; 21(1): 3-33
- Tomberg C, Desmedt JE: Human perceptual processing: inhibition of transient prefrontal-parietal 40 Hz binding at P300 onset documented in non-averaged cognitive brain potentials. *Neurosci Lett* 1998; 255(3): 163-166
- Van Der Stelt O, Geesken R, Gunning WB, Snel J, Kok A: P3 scalp topography to target and novel visual stimuli in children of alcoholics. *Alcohol* 1998; 15: 119-36
- Vernon D, Egner T, Cooper N, Compton T, Neilands C, Sheri A et al. The effect of training distinct neurofeedback protocols on aspects of cognitive performance. *Int J. Psychophysiol* 2003; 47(1): 75-85
- Wolfe F, Smythe HA, Yunus MB, Bennett RM, Bombardier C, Goldenberg DL et al: The American College of Rheumatology 1990 criteria for the classification of fibromyalgia. *Arthritis Rheum* 1990; 33(2): 160-172