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SPECIAL ISSUE

# The Effects of QEEG-Guided Neurofeedback on Postconcussion Syndrome

**Michael Linden, PhD**

Linden Attention Learning Center, San Juan Capistrano, CA

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*This brief report describes the case of a 17-year-old female athlete who suffered two consecutive concussions, producing headache symptoms. The athlete was assessed following the initial concussion with quantitative electroencephalography (QEEG) and an integrated visual and auditory continuous performance test (IVA). Twenty-two sessions of QEEG-guided neurofeedback produced normalization of the QEEG and IVA profiles and a cessation of headaches. A second concussion then produced further abnormalities in the QEEG and the IVA. A final course of 40 sessions of neurofeedback was again successful in normalizing both cortical activity on the QEEG and scores on the IVA.*

## Purpose

This brief report describes the clinical outcomes of quantitative electroencephalogram (QEEG)–guided neurofeedback (NF) on postconcussion syndrome (PCS) with headache symptoms in a 17-year-old female athlete following soccer injuries. There is only limited research on the use of EEG/QEEG recordings as a tool for the physiological assessment of PCS (Duff, 2004; Kutcher et al., 2013; McCrea, Prichep, Powell, Chabot, Barr, 2010). There is a growing interest in the efficacy of NF for treating problems in sport medicine and athletic organizations. The following case narrative is especially valuable, because a QEEG assessment was conducted prior to the traumatic brain injury (TBI) and concussion.

## Method

A 17-year-old female soccer goalie sustained two mild to moderate concussions and developed severe and consistent headaches 5 months postconcussion. Magnetic resonance imaging and medical laboratory tests were negative, and treatment with medications was unsuccessful. The pre- and posttraining assessment included 19 channel QEEG recordings with an eyes closed/eyes open protocol, as well as an integrated visual and auditory continuous performance test (IVA). Using normative databases and visual inspection, EEG data were analyzed to access the location of the PCS injury and to determine the NF training protocol. This patient was trained to decrease slow wave activity at the injury site. The QEEG and IVA were evaluated before, during, and after NF.

## Results

This individual's baseline (in 2005, preconcussion) QEEG indicated normal EEG/QEEG indicative of normal brain functioning. Postconcussion in 2009, the QEEG results indicated abnormal EEG in the right frontal regions where the injury was sustained (see Figure 1).

**Table 1. Theta/Beta electroencephalogram ratios at F4 and Cz over time**

| Baseline (2005) | | Concussion 1 (2009) | Post 22 NF (2009) | Concussion 2 (2010) | Post 60 NF (2011) |
|---|---|---|---|---|---|
| F4 | 2.84 | 3.4 | 2.1 | 3.38 | 2.82 |
| CZ | 5.3 | 4.61 | 3.77 | 5.45 | 3.49 |

*Note:* NF = neurofeedback.

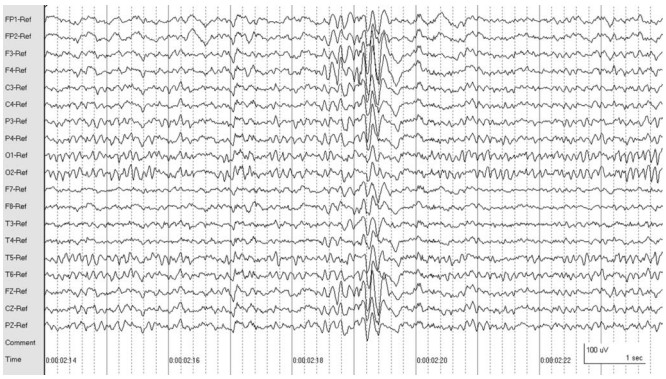

**Figure 1.** The subject's postconcussion/preneurofeedback quantitative electroencephalogram shows significant slow electroencephalogram activity in the frontal location, where her traumatic brain injury had occurred.

**Figure 2.** The athlete during a neurofeedback training session.

The subject was trained in QEEG-guided NF for two 30-minute sessions per week; Figure 2 shows her with an NF training screen. The NF protocols included inhibiting slow EEG activity at F4 after the first concussion and at CZ after the second concussion, directly treating the locations of the two head injuries.[1]

The incidence and severity of headaches were reduced after 2 weeks of NF training. Theta/Beta EEG ratios were also significantly reduced, confirming improved attention (see Table 1; Figure 3). The QEEG following 22 sessions of NF training showed significant normalization (see Figure 4): 40 sessions of additional NF were undertaken after his second concussion, and the final QEEG in 2011 showed a reduction in abnormalities. Table 2 and Figure 3 show the

[1] F4 and CZ are cortical sites based on the international 10–20 system for labeling cortical areas. F4, the approximate site of the first concussion, refers to a cortical site on the right side of the frontal area of the cortex, and CZ, the approximate site of the second concussion, refers to the midline position within the central area of the cortex.

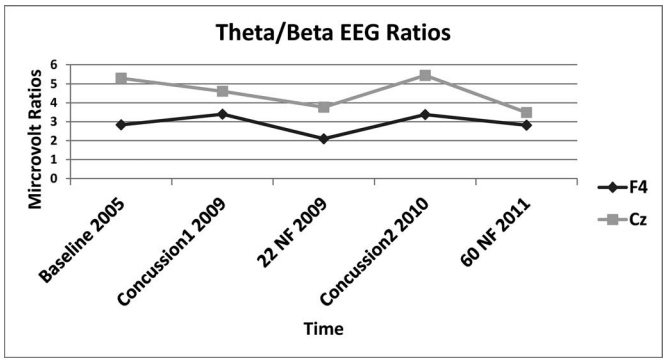


**Figure 3.** Graphic display showing the Theta/Beta ratios at two cortical sites over time.

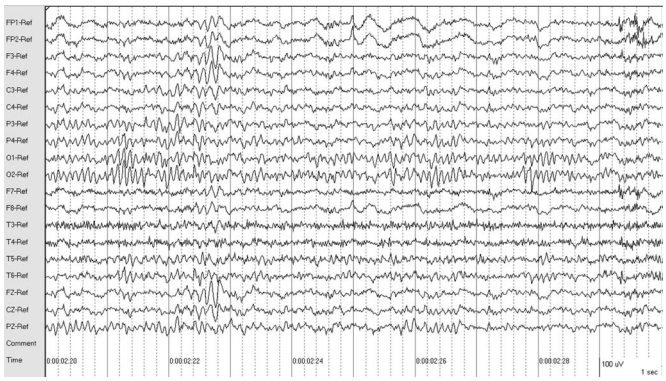

**Figure 4.** Postneurofeedback quantitative electroencephalogram (2009).

improved Theta/Beta ratios following the 2009 NF, the worsening of the Theta/Beta ratio following the 2010 concussion, and the further reduction in the Theta/Beta ratio with additional NF treatment.

The initial IVA profile showed significant evidence of "response impulsivity" and "impaired consistency." Both the IVA Auditory and IVA Visual scores improved following the 22 sessions of NF training in 2009. The IVA scores deteriorated with the second concussion in 2010

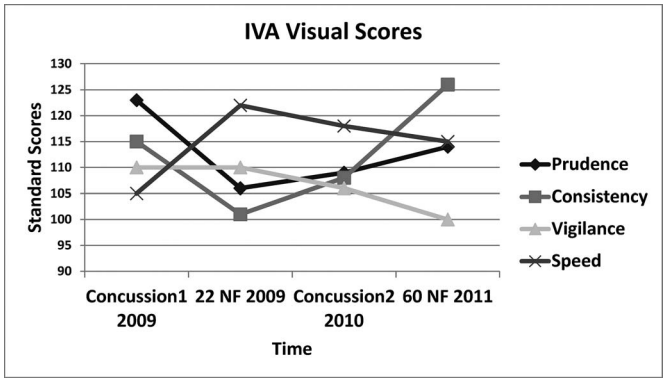


**Figure 5.** Graphic display of the IVA visual scores over time.

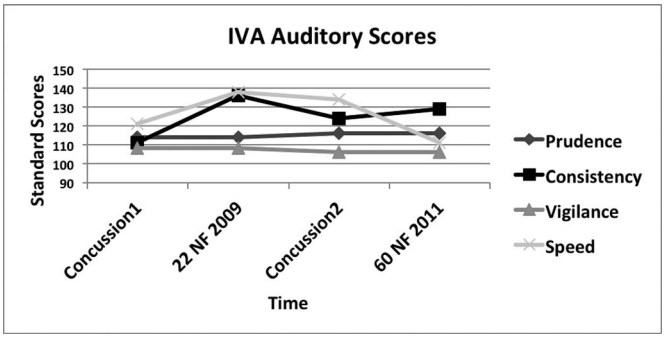


**Figure 6.** Graphic display of the integrated visual and auditory continuous performance test (IVA) auditory scores over time.

and improved again with 40 sessions of additional NF. Figures 5 and 6 show the IVA Auditory and IVA Visual scores at the initial evaluation in 2009, after the initial NF training, after the second concussion, and following the final 2010 training.

## Conclusions

The QEEG/EEG analysis was able to detect the patient's abnormal patterns related to PCS headaches. The QEEG-guided NF training was successful in reducing PCS-related headaches as measured at the close of NF training and at a 2year follow-up.

QEEG shows promise as an assessment of PCS and for guiding NF as a treatment to reduce PCS headaches and improve attention.

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*Michael Linden*

Correspondence: Michael Linden, PhD, Linden Attention Learning Center, 31899 Del Obispo, Suite 150, San Juan Capistrano, CA 92675, email: drmike49@aol.com.