

# Neurofeedback



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## DESCRIPTION

Neurofeedback describes techniques for providing feedback about neuronal activity, as measured by electroencephalogram biofeedback, functional magnetic resonance imaging, or near-infrared spectroscopy, to teach patients to self-regulate brain activity. Neurofeedback may use several techniques in an attempt to normalize unusual patterns of brain function in patients with various psychiatric and central nervous system disorders.

### Disorders of the Central Nervous System

Various disorders involve abnormal brain activity, including autism spectrum disorder, insomnia and sleep disorders, learning disabilities, Tourette syndrome, traumatic brain injury, seizure disorders, premenstrual dysphoric disorder, menopausal hot flashes, depression, stress management, panic and anxiety disorders, posttraumatic stress disorder, substance abuse disorders, eating disorders, migraine headaches, stroke, Parkinson disease, fibromyalgia, tinnitus, and attention-deficit/hyperactivity disorder (ADHD).

### Treatment

Neurofeedback is being investigated for the treatment of a variety of disorders. Neurofeedback may be conceptualized as a type of biofeedback that has traditionally

used the electroencephalogram (EEG) as a source of feedback data. Neurofeedback differs from established forms of biofeedback in that the information fed back to the patient (via EEG tracings, functional magnetic resonance imaging, near-infrared spectroscopy) is a direct measure of global neuronal activity, or brain state, compared with feedback of the centrally regulated physiologic processes, such as tension of specific muscle groups or skin temperature. The patient may be trained to increase or decrease the prevalence, amplitude, or frequency of specified EEG waveforms (e.g., alpha, beta, theta waves), depending on the changes in brain function associated with the particular disorder. It has been proposed that training of slow cortical potentials (SCPs) can regulate cortical excitability and that using the EEG as a measure of central nervous system functioning can help train patients to modify or control their abnormal brain activity. Upregulating or downregulating neural activity with real-time feedback of functional magnetic resonance imaging signals is also being explored. Two EEG-training protocols (training of SCPs, theta/beta training) are typically used in children with ADHD. For training of SCPs, surface-negative and surface-positive SCPs are generated over the sensorimotor cortex. Negative SCPs reflect increased excitation and occur during states of behavioral or cognitive preparation, while positive SCPs are thought to indicate a reduction of cortical excitation of the underlying neural networks and appear during behavioral inhibition. In theta/beta training, the goal is to decrease activity in the EEG theta band (4 to 8 Hz) and increase activity in the EEG beta band (13 to 20 Hz), corresponding to an alert and focused but relaxed state. Alpha-theta neurofeedback is typically used in studies on substance abuse. Neurofeedback protocols for depression focus on alpha interhemispheric asymmetry and theta/beta ratio within the left prefrontal cortex. Neurofeedback for epilepsy has focused on sensorimotor rhythm up-training (increasing 12 to 15 Hz activity at motor strip) or altering SCPs. It has been proposed that learned alterations in EEG patterns in epilepsy are a result of operant conditioning and are not conscious or voluntary. A variety of protocols have been described for the treatment of migraine headaches.

## **Attention-Deficit/Hyperactivity Disorder**

### **Clinical Context and Therapy Purpose**

The purpose of neurofeedback is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as behavioral therapy and pharmacologic therapy, in patients with attention-deficit/hyperactivity disorder (ADHD).

### **Population**

The relevant population of interest is individuals with attention deficit hyperactivity disorder (ADHD).

Attention deficit hyperactivity disorder manifests in children as symptoms of hyperactivity, impulsivity, and/or inattention, and affects cognitive, academic, behavioral, emotional, and social function. It is one of the most common neurobehavioral disorders of childhood.

## Interventions

The therapy being considered is neurofeedback.

Neurofeedback describes techniques for providing feedback about neuronal activity, as measured by electroencephalogram (EEG) biofeedback, functional magnetic resonance imaging, or near-infrared spectroscopy, to teach patients to self-regulate brain activity. Neurofeedback may use several techniques to normalize unusual patterns of brain function in patients with various psychiatric and central nervous system disorders.

## Comparators

Guidelines or treatment of ADHD in children and adolescents generally recommend parent training in behavior management, Food and Drug Administration (FDA)-approved medications (e.g., stimulants), and educational interventions. ADHD also occurs in adults, with a prevalence of approximately 3.4% to 4.4% of US adults. Guidelines for the treatment of ADHD in adults include recommendations for psychoeducation, pharmacotherapy, and cognitive behavioral therapy.

Comparators of interest include behavioral therapy and pharmacologic therapy. Treatment includes support groups, cognitive behavioral therapy, anger management, counseling, psychology, psychoeducation, family therapy, and applied behavior analysis. Medications for treatment include stimulants, cognition-enhancing medication, and antihypertensive drugs.

## Outcomes

The general outcomes of interest are symptoms, functional outcomes, and quality of life.

### Outcomes of Interest for Individuals with ADHD

Outcomes	Details
Symptoms	Outcomes as reported by assessors (parents most-often, or teachers, usually unblinded and with a high risk of bias);  Attention Deficit Hyperactivity Disorder-Rating Scale (ADHS-RS, domains of inattention, hyperactivity/impulsiveness, and combined scores);  Conners scale;  Fremdbeurteilungsbogen für Hyperkinetische Störungen (FBB-HKS)  [Timing: greater than 1 year]

ADHD: attention-deficit/hyperactivity disorder.

### Health Outcome Measures Relevant to ADHD in Children and Adolescents

Outcome	Measure (Units)	Description	Clinically Meaningful Difference (If Known)
Attention-Deficit/Hyperactivity Disorder-Rating Scale (ADHD-RS)	Scale from 0 to 54  Higher scores indicate more symptoms  18 items are grouped into 2 subscales: hyperactivity/impulsivity and inattentiveness	Short scale that can be completed by parent, teacher, or investigator based on information provided by teacher or parent	Change between 5.2 and 7.7 points or 30% mean total score change between treatment groups
Conners Parent Rating Scale for ADHD	Scale from 0 to 144  Higher scores indicate more symptoms	Used by clinicians and researchers to assess parents' perception of children's behavior in the classroom  Assesses conduct problems, learning problems, psychometric problems, impulsivity and hyperactivity, and anxiety	Not defined
Conners 3rd Edition-Parent (Conners 3-P)	Scale with 9 subscales  Higher scores indicate more symptoms	Used by parents to assess symptoms of ADHD and common comorbid problems	Not defined
Fremdbeurteilungsbogen für Hyperkinetische Störungen (FBB-HKS)	Scale with 20 items	Items can be rated by	Not defined

	Higher scores indicate more symptoms	parents or teacher	
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ADHD: attention-deficit/hyperactivity disorder.

In studies of neurofeedback, the duration of intervention was at least 1 month and ranged from 1 to 12 months. Follow-up studies of randomized controlled trials (RCTs) that reported longer-term outcomes have reported results at 6 months.

## Review of Evidence

### Systematic Reviews with Meta-Analysis

Numerous systematic reviews with meta-analyses have compared neurofeedback versus other treatments for attention-deficit/hyperactivity disorder (ADHD) in children, adolescents, and adults. Comparators included methylphenidate, biofeedback, cognitive behavioral therapy, cognitive training, or physical activity. The results of these analyses generally demonstrated either small to moderate or no benefit of neurofeedback versus other treatments for ADHD symptoms.

### ECRI Institute Evidence Review for use of Neurofeedback in ADHD

The report focuses on how well neurofeedback (NF) works compared with pharmacologic and nonpharmacologic treatments for improving attention and behavioral control in children and adolescents with attention deficit hyperactivity disorder (ADHD).

This evidence review concluded the following: Evidence from 3 meta-analyses of low-quality studies and 3 additional randomized controlled trials (RCTs) shows that NF is less effective than pharmacotherapy and behavioral therapy for managing ADHD symptoms. Whether NF is more effective than inactive interventions (sham NF, waiting list, attention training, physical exercise) or placebo is unclear because studies reported mixed findings. Studies used different NF protocols, outcome assessment methods, and patient groups. Larger RCTs using standardized methods for NF are needed to assess comparative safety and effectiveness. Clinical guidelines state that evidence is insufficient to recommend NF for ADHD management.

### Randomized Controlled Trails not Included in the Meta-Analysis

In 2022, Hasslinger et. al., published a multi-arm, pragmatic, RCT [NCT01841151] in 202 children and adolescents with attention-deficit/hyperactivity disorder (ADHD) that evaluated the efficacy of 2 neurofeedback treatments (slow cortical potential [SCP] and Live Z-score) compared to working-memory training (active comparator) and Treatment-as-usual (TAU; passive comparator). N=202 children/adolescents aged 9 to 17 years with ADHD participated. The primary outcome measure was multi-report (self-, teacher-, and parent-report) ADHD core symptoms on the Conners-3, assessed at baseline, posttreatment, and 6-months follow-up. Data were analyzed using a linear mixed model. Between-group differences were scarce and did not show a distinct pattern. Superiority of LZS over TAU at endpoint were observed for teacher-rated measures only, while significant differences between SCP and TAU were restricted to posttreatment measurements. Contrary to expectations, LZS outperformed SCP at endpoint for teacher-

rated hyperactivity (-5.37; 95% CI: -10.14 to -0.60;  $p=.028$ ;  $d=-.36$ ) and overall ADHD symptoms (-2.20; -4.18 to -0.22;  $p=.030$ ;  $d=-.41$ ). There was no indication that either form of NF was superior to WMT. No severe adverse events were reported during the trial, whereas transient stress-related problems were quite frequent. Overall, the results from this pragmatic trial do not provide convincing support for broad implementation of neurofeedback (NF) in child and adolescent psychiatric services. Future research should try to clarify for whom and under what circumstances NF might be a viable treatment option.

### **Section Summary**

Several systematic reviews with meta-analysis with an additional randomized controlled trial (RCT) have compared neurofeedback with methylphenidate, biofeedback, cognitive behavioral therapy, cognitive training, or physical activity. These studies found either small to moderate or no benefit of neurofeedback, and sustained long-term benefit (e.g., at 6 to 13 months) has not been consistently demonstrated. Studies using active controls have suggested that at least part of the effect of neurofeedback might be due to attention skills training, biofeedback, relaxation training, and/or other nonspecific effects. Two of the RCTs indicated that any beneficial effects were more likely to be reported by evaluators unblinded to treatment (parents), than by evaluators blinded (teachers) to treatment, which would suggest bias in the nonblinded evaluations. Moreover, a meta-analysis found no effect of neurofeedback on objective measures of attention and inhibition. Additional research with blinded evaluation of outcomes is needed to demonstrate the effect of neurofeedback on attention-deficit/hyperactivity disorder (ADHD).

### **Disorders Other than Attention Deficit-Hyperactivity Disorder**

#### **Clinical Context and Therapy Purpose**

The purpose of neurofeedback is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as behavioral therapy and pharmacologic therapy, in patients with disorders other than attention-deficit/hyperactivity disorder (ADHD).

#### **Populations**

The relevant population of interest is individuals with disorders other than attention-deficit/hyperactivity disorder (ADHD), including psychiatric, central nervous system, or pain disorders.

#### **Interventions**

The therapy being considered is neurofeedback.

#### **Comparators**

Comparators of interest include behavioral therapy and pharmacologic therapy.

**Outcomes**

The general outcomes of interest are symptoms, functional outcomes, and quality of life.

**Outcomes of Interest for Individuals with Disorders other than ADHD**

<b>Outcomes</b>	<b>Details</b>
Reduction of Symptoms as Observed by Parents and Patients	Attention Switching Task; Impact of Pediatric Epilepsy Scale; PTSD symptoms  [Timing: 6 weeks]

**Health Outcome Measures Relevant to Disorders other than ADHD**

<b>Outcome</b>	<b>Measure (Units)</b>	<b>Description</b>	<b>Clinically Meaningful Difference (if Known)</b>
Attention Switching Task	msec  Longer duration indicates more symptoms	Computerized task measuring ability to adjust behavior in accordance with changing task goals	Not defined
Impact of Pediatric Epilepsy Scale	Scale from 0 to 33  Higher scores indicate more symptoms	Questionnaire administered to parent or guardian measuring domains of academic improvement, social adaptation, and self-esteem	Not defined
PTSD symptoms	Various questionnaires  Higher scores indicate more symptoms	Various questionnaires administered to patients measuring the frequency and intensity of PTSD symptoms	Not defined
Sleep efficiency	Percentage  Lower values indicate more symptoms	Measure of percentage of total time in bed spent asleep	Not defined
Sleep fragmentation	Occurrences  Higher values indicate more symptoms	Measure of the number of awakening episodes by	Not defined

		polysomnography or patient diary	
Total sleep time	Minutes  Lower values indicate more symptoms	Measure of time spent asleep among total recording time	Not defined

ADHD: attention-deficit/hyperactivity disorder; PTSD: post-traumatic stress disorder.

## Review of Evidence

### Chronic Insomnia

A systematic review in 2019 by Melo et. al., included 7 randomized controlled trials (RCTs) of biofeedback techniques, including neurofeedback, in the treatment of chronic insomnia. The authors identified conflicting results in comparisons of neurofeedback with other cognitive behavioral therapy techniques, placebo, and no treatment. Many outcomes demonstrated no significant differences between comparison groups. Many of the studies had a high risk of bias related to blinding of participants and personnel and incomplete outcome data.

### Epilepsy

A randomized controlled trial (RCT) in 2019, Morales-Quezada et. al., randomized children with focal epilepsy to sensorimotor rhythm neurofeedback, SCP neurofeedback, or sham neurofeedback for 25 sessions over 5 weeks. At the end of the intervention period, only the sensorimotor rhythm neurofeedback group demonstrated significant improvement in the activity switching task and all groups demonstrated significant improvements in quality of life.

### Other Disorders

Review of the peer reviewed medical literature assessing neurofeedback for psychiatric and neurological disorders have identified small studies to include case reports, case series, comparative cohorts, and small randomized controlled trials (RCTs) for the following conditions:

- Anxiety
- Asperger syndrome
- Autism spectrum disorder
- Cigarette cravings
- Chronic pain
- Cognitive impairment
- Depression
- Depression, pain, or fatigue in patients with multiple sclerosis
- Depression in alcohol addiction
- Dissociative identity disorder
- Fall risk
- Fibromyalgia

- Insomnia
- Headache
- Lower back pain
- Multiple sclerosis
- Overweight and obesity
- Obsessive-compulsive disorder
- Parkinson disease
- Schizophrenia
- Stroke
- Tinnitus
- Tourette syndrome

### **Pediatric Brain Tumor Survivors**

In 2016, De Ruiter et. al., reported on a multicenter, triple-blind RCT of neurofeedback in 80 pediatric brain tumor survivors who had cognitive impairments. The specific neurofeedback module was based on individual EEG, and participants, parents, trainers, and researchers handling the data were blinded to assignment to the active or sham neurofeedback module. At the end of training and 6-month follow-up, there were no significant differences between the neurofeedback and sham feedback groups on the primary outcome measures for cognitive performance, which included attention, processing speed, memory, executive functioning, visuomotor integration, and intelligence.

### **Post-Traumatic Stress Disorder**

In 2020, Steingrimsdottir in a systematic review and meta-analysis evaluated 4 RCTs of adults with post-traumatic stress disorder (PTSD) treated with neurofeedback. Compared with sham neurofeedback, no treatment or other treatment, neurofeedback was associated with significant improvement in PTSD symptoms. Other primary outcomes were only reported in 1 trial each, and the authors concluded there was uncertainty regarding the ability of neurofeedback to improve PTSD symptoms, self-rated suicidality, executive cognitive functioning, and medication use. All studies were at moderate to high risk for bias and were assessed as having some indirectness and imprecision.

### **Substance Abuse**

A systematic review by Sokhadze et. al., of neurofeedback as a treatment for substance abuse disorders described difficulties in assessing the efficacy of neurofeedback and other substance abuse treatments. Study shortcomings included a lack of clearly established outcome measures, differing effects of the various drugs, the presence of comorbid conditions, the absence of a criterion standard treatment, and use as an add-on to other behavioral treatment regimens. Reviewers concluded that alpha-theta training, when combined with an inpatient rehabilitation program for alcohol dependency or stimulant abuse, would be classified as level 3 or "probably efficacious." This level is based on beneficial effects shown in multiple observational studies, clinical studies, wait-list control studies, or within-subject or between-subject replication studies. Reviewers also noted that few large-scale studies of neurofeedback in addictive disorders have been

reported and that the evidence for alpha-theta training has not been shown to be superior to sham treatment.

### **Section Summary**

The evidence for neurofeedback in individuals with disorders other than attention-deficit/hyperactivity disorder (ADHD) includes case reports, case series, comparative cohorts, small randomized controlled trials (RCTs), and systematic reviews of these studies. For these disorders, the evidence is poor, and several questions regarding clinical efficacy remain unanswered. Larger RCTs that include either a sham or active control are needed to evaluate the effect of neurofeedback for these conditions.

### **Summary of Evidence**

For individuals who have attention-deficit/hyperactivity disorder (ADHD) who receive neurofeedback, the evidence includes randomized controlled trials (RCTs) and systematic reviews with meta-analyses. Several meta-analyses and an additional RCTs (n range, 144 to 202 patients) have compared neurofeedback with methylphenidate, biofeedback, cognitive behavioral therapy, cognitive training, physical activity, or sham neurofeedback. Collectively, these studies found either small or no benefit of neurofeedback. A meta-analysis also found no effect of neurofeedback on objective measures of attention and inhibition. Studies that used active controls have suggested that at least part of the effect of neurofeedback may be due to attention skills training, relaxation training, and/or other nonspecific effects. Also, the beneficial effects of neurofeedback are more likely to be reported by evaluators unblinded to treatment (parents) than by evaluators blinded to treatment (teachers), suggesting bias in the nonblinded evaluations. Additional research with blinded evaluation of outcomes is needed to demonstrate the effect of neurofeedback on ADHD. However, the completion dates for some registered trials of neurofeedback in ADHD have passed without publication of results, suggesting the potential for publication bias. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have disorders other than attention-deficit/hyperactivity disorder (ADHD) (e.g., chronic insomnia, epilepsy, substance abuse, pediatric brain tumors, and PTSD) who receive neurofeedback, the evidence includes case reports, case series, comparative cohorts, small randomized controlled trials (RCTs), and systematic reviews. For these other disorders, including psychiatric, neurologic, and pain syndromes (*see above Other Disorders*), the evidence is poor, and several questions concerning clinical efficacy remain unanswered. Larger RCTs that include either a sham or active control are needed to evaluate the effect of neurofeedback for these conditions. However, the completion dates for some registered trials of neurofeedback in disorders other than ADHD have passed without publication of results, suggesting the potential for publication bias. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

## Practice Guidelines and Position Statements

### American Academy of Pediatrics (ACP)

In 2019, the American Academy of Pediatrics (ACP) clinical practice guideline for the diagnosis, evaluation, and treatment of attention deficit/hyperactivity disorder in children or adolescents states the following: “Some nonmedication treatments for ADHD-related problems have either too little evidence to recommend them or have been found to have little or no benefit. These include mindfulness, cognitive training, diet modification, EEG biofeedback, and supportive counseling.”

## PRIOR APPROVAL

Not applicable.

## POLICY

- **See Related Medical Policies**
  - [Biofeedback 02.01.04](#)

Neurofeedback (also known as electroencephalogram (EEG) biofeedback), is considered **investigational** for all indications, because there is insufficient evidence demonstrating an impact on improved net health outcomes.

### Home Neurofeedback Devices

In-home neurofeedback devices including but not limited to the following are considered **investigational** for all indications because the evidence in the published peer-reviewed medical literature does not support the effectiveness of home neurofeedback devices as the results of the clinical trials were limited due to the inability to monitor the use of the home neurofeedback used by subjects in these trials. The evidence is insufficient to support a conclusion concerning net health outcomes or benefits associated with this therapy:

- Brain Master
- EEG biofeedback device: GSR/Tamp2xTM and RESPeRate
- EEG glasses
- EEG headwear
- NeurOptimal neurofeedback
- QEEG (Quantitative EEG)

## **PROCEDURE CODES AND BILLING GUIDELINES**

To report provider services, use appropriate CPT\* codes, Alpha Numeric (HCPCS level 2) codes, Revenue codes, and/or ICD diagnosis codes.

- 90901 Biofeedback training by any modality (when utilized for EEG neurofeedback)
- E1399 Durable Medical Equipment, miscellaneous (may be utilized for EEG neurofeedback device: Brain Master, EEG biofeedback devise: GSR/Tamp2xTM and RESPeRate, EEG glasses, EEG headwear, NeurOptimal neurofeedback, NeurOptimal neurofeedback or QEEG [Quantitative EEG])

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<b>POLICY HISTORY</b>		
<b>Date</b>	<b>Reason</b>	<b>Action</b>
July 2022		New policy created and content moved from Biofeedback 02.01.04

New information or technology that would be relevant for Wellmark to consider when this policy is next reviewed may be submitted to:

Wellmark Blue Cross and Blue Shield

Medical Policy Analyst

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