

# Cigna Medical Coverage Policy- Therapy Services Biofeedback

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## INSTRUCTIONS FOR USE

*Cigna / ASH Medical Coverage Policies are intended to provide guidance in interpreting certain standard benefit plans administered by Cigna Companies. Please note, the terms of a customer's particular benefit plan document may differ significantly from the standard benefit plans upon which these Cigna / ASH Medical Coverage Policies are based. In the event of a conflict, a customer's benefit plan document always supersedes the information in the Cigna / ASH Medical Coverage Policy. In the absence of a controlling federal or state coverage mandate, benefits are ultimately determined by the terms of the applicable benefit plan document. Determinations in each specific instance may require consideration of:*

- 1) the terms of the applicable benefit plan document in effect on the date of service*
- 2) any applicable laws/regulations*
- 3) any relevant collateral source materials including Cigna-ASH Medical Coverage Policies and*
- 4) the specific facts of the particular situation*

*Where coverage for care or services does not depend on specific circumstances, reimbursement will only be provided if a requested service(s) is submitted in accordance with the relevant guidelines and criteria outlined in this policy, including covered diagnosis and/or procedure code(s) outlined in the Coding Information section of this policy. Reimbursement is not allowed for services when billed for conditions or diagnoses that are not covered under this policy. When billing, providers must use the most appropriate codes as of the effective date of the submission. Claims submitted for services that are not accompanied by covered code(s) under this policy will be denied as not covered.*

*Cigna / ASH Medical Coverage Policies relate exclusively to the administration of health benefit plans.*

*Cigna / ASH Medical Coverage Policies are not recommendations for treatment and should never be used as treatment guidelines.*

*Some information in these Coverage Policies may not apply to all benefit plans administered by Cigna. Certain Cigna Companies and/or lines of business only provide utilization review services to clients and do not make benefit determinations. References to standard benefit plan language and benefit determinations do not apply to those clients.*

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## **GUIDELINES**

**Coverage for biofeedback varies across plans. Refer to the customer's benefit plan document for coverage details.**

**If coverage is available for biofeedback, the following conditions of coverage apply.**

### **Medically Necessary**

**Biofeedback performed by a licensed healthcare professional is considered medically necessary for ANY of the following conditions\*:**

- Chronic constipation with dyssynergic defecation (adults only)

- Fecal incontinence for patients with:
  - some degree of rectal sensation, and
  - ability to contract the sphincter voluntarily, and
  - failure/intolerance/contraindication of treatment with dietary changes, devices or drugs
- Stress, urgency, mixed, or overflow urinary incontinence when there is failure/intolerance/contraindication of other nonpharmacologic treatment (e.g., bladder training and/or pelvic floor muscle training [PFMT]) (children and adults)
- Migraine and tension headaches (children and adults) as part of a comprehensive treatment plan
- Muscle re-education of specific extremity muscle groups or for treating pathological muscle abnormalities of spasticity, incapacitating muscle spasm, or weakness when:
  - Patient is diagnosed with stroke, and
  - Failure/intolerance/contraindication of conventional treatments (e.g. modalities, massage, soft tissue mobilization, exercise)
- Refractory levator ani syndrome (e.g. proctalgia fugax, chronic anal pain syndrome, anal spasm) with dyssynergic defecation when:
  - Condition is not neurological or disease-based
  - Failure/intolerance/contraindication of conservative treatment including:
    - high-fiber diet
    - withdrawal of drugs that cause constipation (e.g., calcium channel blockers, narcotics) or diarrhea (e.g., antibiotics, quinidine, theophylline)
    - perineal strengthening exercises
    - rectal massage
    - warm baths, and
    - drug therapy (e.g., muscle relaxants, non-narcotic analgesics, and sedatives)

**\*NOTE:**

- Patients must be cognitively intact and willing and motivated to learn and practice the specific tasks needed to correct/improve their problems.
- There should be a written treatment plan which must include all of the following information:
  - The specific diagnosis/conditions to be treated
  - Long- and short-term goals
  - Measurable objectives
  - The time frame and the frequency of treatment in which the goals and objectives will be achieved.

**Not Medically Necessary**

**Biofeedback for ANY other indication is considered not medical necessary, including but not limited to:**

- As a rehabilitation modality for spasmodic torticollis, spinal cord injury, or following knee surgeries
- Attention deficit hyperactivity disorder (ADHD)
- Autism
- Bell's palsy (idiopathic facial paralysis)
- Cardiovascular diseases (e.g., heart failure)
- Chemotherapy-induced peripheral neuropathy
- Childhood apraxia of speech
- Chronic fatigue syndrome
- Chronic pain (e.g., back pain, fibromyalgia, neck pain) other than migraine and tension headache
- Epilepsy
- Essential hypertension (e.g., by means of the RESPeRATE Device)
- Facial pain
- Functional dysphonia

- Improvement of anorectal/bowel functions after sphincter-saving surgery for rectal cancer
- Neurogenic bladder
- Non-neuropathic voiding disorders
- Labor pain
- Prophylaxis of medication overuse headache and pediatric migraine
- Raynaud's disease/phenomenon
- Rheumatoid arthritis
- Sleep bruxism
- Spasticity secondary to cerebral palsy
- Temporomandibular joint (TMJ) syndrome
- Toe-out gait modification/retraining in people with knee osteoarthritis
- Vaginismus
- Vulvodynia

### **Experimental, Investigational, Unproven**

**EACH of the following is considered experimental, investigational or unproven:**

- In-home biofeedback devices
- Electroencephalography (EEG) biofeedback or neurofeedback for any indication including but not limited to:
  - addictions
  - anxiety disorders
  - attention deficit hyperactivity disorder (ADHD)
  - autism spectrum disorders
  - brain injury
  - depression
  - dyslexia
  - epilepsy
  - fibromyalgia
  - insomnia
  - learning disabilities
  - pervasive developmental delay/intellectual disability
  - substance use disorder
  - tinnitus
- InTandem Neurorehabilitation System for any indication

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## **Coding Information**

### **Notes:**

1. This list of codes may not be all-inclusive since the American Medical Association (AMA) and Centers for Medicare & Medicaid Services (CMS) code updates may occur more frequently than policy updates.
2. Deleted codes and codes which are not effective at the time the service is rendered may not be eligible for reimbursement.

**Considered Medically Necessary when criteria in the applicable policy statements listed above are met:**

<b>CPT®*</b> <b>Codes</b>	<b>Description</b>
90901	Biofeedback training by any modality
90912	Biofeedback training, perineal muscles, anorectal or urethral sphincter, including EMG and/or manometry, when performed; initial 15 minutes of one-on-one physician or other qualified health care professional contact with the patient
90913	Biofeedback training, perineal muscles, anorectal or urethral sphincter, including EMG and/or manometry, when performed; each additional 15 minutes of one-on-one physician or other

<b>CPT®* Codes</b>	<b>Description</b>
	qualified health care professional contact with the patient (List separately in addition to code for primary procedure)

<b>ICD-10-CM Diagnosis Codes</b>	<b>Description</b>
G43.001- G43.019	Migraine without aura
G43.101- G43.119	Migraine with aura
G43.401- G43.419	Hemiplegic migraine
G43.501- G43.519	Persistent migraine aura without cerebral infarction
G43.601- G43.619	Persistent migraine aura with cerebral infarction
G43.701- G43.719	Chronic migraine without aura
G43.801- G43.839	Other migraine
G43.901- G43.919	Migraine, unspecified
G43.E01- G43.E19	Chronic migraine with aura
G44.201- G44.209	Tension-type headache, unspecified
G89.3	Neoplasm related pain (acute) (chronic)
I63.00- I63.9	Cerebral infarction
K59.00	Constipation, unspecified
K59.01	Slow transit constipation
K59.02	Outlet dysfunction constipation
K59.09	Other constipation
K59.4	Anal spasm
N39.3	Stress incontinence (female) (male)
N39.41	Urge incontinence
N39.42	Incontinence without sensory awareness
N39.43	Post-void dribbling
N39.44	Nocturnal enuresis
N39.45	Continuous leakage
N39.46	Mixed incontinence
N39.490	Overflow incontinence
N39.498	Other specified urinary incontinence
R15.0- R15.9	Fecal incontinence
R32	Unspecified urinary incontinence
R39.9	Unspecified symptoms and signs involving the genitourinary system

**Considered Not Medically Necessary:**

ICD-10-CM Diagnosis Codes	Description
	All other codes

### **Biofeedback Devices**

#### **Considered Experimental/Investigational/Unproven:**

CPT®* Codes	Description
E0746	Electromyography (EMG), biofeedback device
E3200	Gait modulation system, rhythmic auditory stimulation, including restricted therapy software, all components and accessories, prescription only

ICD-10-CM Diagnosis Codes	Description
	All codes

**\*Current Procedural Terminology (CPT®) ©2024 American Medical Association: Chicago, IL.**

### **DESCRIPTION**

This guideline includes various indications for biofeedback, electroencephalography (EEG) biofeedback or neurofeedback, and in-home biofeedback devices.

### **GENERAL BACKGROUND**

Biofeedback therapy provides visual, auditory or other evidence of the status of certain body functions so that a person can exert voluntary control over the functions, and thereby alleviate an abnormal bodily condition. Biofeedback therapy often uses electrical devices to transform bodily signals indicative of such functions as heart rate, blood pressure, skin temperature, salivation, peripheral vasomotor activity, and gross muscle tone into a tone or light, the loudness or brightness of which shows the extent of activity in the function being measured. It emphasizes relaxation, enhancement of muscle contraction and/or stress-reduction. Biofeedback is considered an alternative medicine technique (National Center for Complementary and Alternative Medicine [NCCAM], 2017; Holroyd, et al., 2003; Karmody, 2003; Kiresuk, et al., 2005).

There are several different types of biofeedback. The biofeedback modality selected for therapy depends on the condition to be treated. EMG biofeedback measures muscle tension and is proposed for the treatment of chronic muscle stiffness, injury and pain (e.g., neck and back pain); headaches, asthma, incontinence; and intestinal symptoms. Thermal or temperature biofeedback measures skin temperature and is proposed for the treatment of circulatory disorders, such as headaches, hypertension, and Raynaud's phenomenon. Galvanic skin response (GSR) biofeedback, also called electrodermal response (EDR), electrodermal activity (EDA), skin conductance response (SCR) or skin conductance level (SCL) biofeedback, measures electrical conductance in the skin associated with sweat gland activity and perspiration. GSR is proposed for the treatment of anxiety disorders and phobias. Another form of biofeedback is electroencephalogram (EEG) biofeedback, also called neurofeedback, brainwave biofeedback or neurotherapy, which measures alpha (associated with relaxation and meditation) and theta (associated with focused attention) brainwave activity. It is proposed to counterbalance genetic and environmental tendencies by learning to alter brain wave patterns. EEG biofeedback has been proposed for the treatment of multiple conditions including insomnia, attention deficit hyperactivity disorder (ADHD), dyslexia, anxiety disorders, autism spectrum disorders, epilepsy, addictions, tinnitus, brain injury, depression, learning disabilities, pervasive developmental delay/intellectual disability, fibromyalgia, dyslexia. However, the evidence in the published peer-reviewed scientific literature does not support the efficacy of EEG biofeedback. The three most commonly used forms of biofeedback therapy are: (1) electromyography (EMG), which measures muscle tension;

(2) thermal biofeedback, which measures skin temperature; and (3) neurofeedback or electroencephalography (EEG), which measures brain wave activity. Various forms of biofeedback appear to be effective for a narrow range of health problems.

Forms of biofeedback have been in use in physical therapy for more than 50 years, where it is beneficial in the management of neuromuscular disorders. Biofeedback techniques have shown benefit when used as part of a physical therapy program for people with motor weakness or dysfunction after stroke, after orthopedic surgery, or due to other neuromuscular diseases. These methods are getting better at training for complex task-oriented activities like walking and grasping objects as technology continues to advance. Aside from neuromuscular retraining, the most common use for biofeedback is to help with chronic symptom management due to anxiety, pain, and urinary and fecal incontinence. These techniques focus on managing the overactive sympathetic response and coordinating muscle activity in gastrointestinal and genitourinary tracts. Biofeedback techniques are generally regarded as safe and free of side effects. For this reason, they are incorporated into treatment plans despite lacking strong evidence to support their benefits (Malik and Dua, 2021).

Although there are numerous biofeedback devices available for home use, biofeedback should be performed in a clinical setting with the continuous presence of the physician or by a qualified non-physician practitioner. Continuous presence requires one-on-one face-to-face involvement with the patient and practitioner during training. Qualified non-physician practitioners include physical and occupational therapists in independent practice, Nurse Practitioners, Physician Assistants, and Clinical Nurse Specialists. Examples of home devices include: StressEraser® (Helicor, Inc., New York, NY) for mind and body relaxation; BrainMaster (BrainMaster Technologies, Inc., Oakwood Village, OH) EEG biofeedback devices; GSR/Temp2XTM (Biofeedback Instrument Corp., New York, NY) temperature biofeedback system; and RESPeRate (Intercure Ltd., Lod, Israel) which uses therapeutic paced breathing to lower blood pressure.

### **Urinary Incontinence**

Urinary incontinence (UI) affects people of all ages, especially elderly women. Among adults, there are 4 prevalent types of UI: (1) stress incontinence (closure problem), (2) urge incontinence (storage problem), (3) overflow incontinence, and (4) mixed stress and urge incontinence. In women, stress incontinence is generally caused by an incompetent urethral mechanism which arises from damage to the sphincter(s) or weakening of the bladder neck support that typically occurred during childbirth. In men, stress incontinence is usually a consequence of operations for benign prostatic hypertrophy (BPH) or prostate cancer. Urge incontinence is usually associated with an over-activity of the detrusor muscle. When the involuntary contraction of the detrusor muscle is associated with a neurological deficit, it is known as detrusor hyperreflexia. On the other hand, when detrusor over-activity is not associated with any neurological deficit, it is labeled as detrusor instability (unstable bladder). Overflow incontinence may be due to an underactive detrusor muscle or obstruction of the urethra. In men, overflow incontinence associated with obstruction is usually due to prostatic hyperplasia. Urethral obstruction in women may occur as a consequence of anti-incontinence operation or severe prolapse of the uterus or relaxation of the anterior vaginal wall with cystocele or cystourethrocele.

First line treatment of urinary incontinence (stress, urgency, mixed) consists of behavioral treatments with an emphasis on improving quality of life because of their relatively non-invasive and low risk nature. Initial treatment includes lifestyle modifications and pelvic floor muscle exercise (Kegel exercises). Biofeedback is used as an adjunct to pelvic floor muscle exercises. By providing individuals with concurrent feedback on muscle tone, biofeedback is intended to improve the patient's ability to perform pelvic muscle exercises. Augmented versions also use abdominal and perineal EMG recordings to demonstrate improper contraction of abdominal and gluteal muscles. Pelvic muscle exercises can aid in strengthening the voluntary periurethral and pelvic muscles needed to maintain urinary continence since contractions of these muscles raise the urethral pressure. This form of exercise is indicated for women with stress incontinence, men with incontinence following prostatic surgery, and patients with urge incontinence. Depending on the type of UI, patients are taught to contract the pelvic floor muscles, relax the detrusor and the abdominal muscles, and/or contract the sphincters.

Biofeedback has been suggested to be useful in teaching patients with UI pelvic muscle exercises because it relays to them whether they are contracting the right muscle(s) and provides positive reinforcements as they acquire the skill during training sessions.

### **Fecal Incontinence**

Fecal incontinence is the inability to control bowel movements and may involve leakage of stool. Causes of fecal incontinence include severe constipation, chronic diarrhea, overuse of laxatives, damage to the anal sphincter muscles or nerves, anal surgical procedures, spinal cord injury and stroke. Treatment includes changes in dietary habits, pelvic floor muscle exercises and pharmacotherapy. Fecal incontinence (FI) is fairly common in the elderly and children. Dysfunction/abnormality of one or more of many factors; such as mental function, stool volume and consistency, anorectal sensation and reflexes and anal sphincter function, can result in FI. There are various methods for the treatment of FI including behavioral therapies, drug therapies, and surgical intervention. Various biofeedback techniques have also been used in the management of FI. In particular, external anal sphincter (EAS) biofeedback training has been shown to be effective in treating FI. This technique teaches patients to increase the strength of contraction of their EAS in response to rectal distention. There is evidence that biofeedback techniques are safe and effective in the treatment of patients with fecal incontinence, especially those who have some degree of rectal sensation and ability to contract the sphincter voluntarily. Biofeedback training has been demonstrated to restore continence or reduce the frequency of incontinence in patients with fecal incontinence with satisfactory long term results.

### **Levator Ani Syndrome**

Levator ani syndrome (LAS) is characterized by chronic or recurring episodes of rectal pain or aching in patients with normal structural examinations of the rectum and pelvic floor. Patients with these findings are considered "highly likely" to have LAS if they experience tenderness on palpation of the levator muscles or to have "possible" LAS if they do not experience tenderness. This pain is usually unrelated to a bowel movement, and there appear to be no structural abnormalities or underlying conditions responsible for the symptoms. Though the exact cause is unknown, it is commonly believed that chronic tension of the pelvic floor muscles plays a role in levator ani syndrome. Another theory is that inflammation in the pelvic area is a contributing factor. People may be at higher risk of levator ani syndrome after childbirth or following surgery on the pelvic area, anus, or spine.

### **Chronic Constipation**

Constipation is one of the most common gastrointestinal complaints in the United States affecting at least 10 % of the general population, and 25 % of the elderly. It is not a disease, but a symptom of various diseases/disorders of mixed etiologies and mechanisms. Constipation is defined as the occurrence of 2 or more of the following symptoms in the previous 12 months (without the use of laxatives): (1) fewer than 3 bowel movements per week, (2) excessive straining during at least 25 % of bowel movements, (3) a feeling of incomplete evacuation after at least 25 % of bowel movements, and (4) passage of hard or pellet-like stool during at least 25 % of bowel movements (Whitehead et al, 1991). Causes for constipation may be colorectal (e.g., malignancy, diverticular disease, pelvic floor dysfunction, and anal fissure), drug-induced (e.g., opiate analgesics, calcium and aluminum-containing antacids, anti-diarrheal agents, anti-depressants, and anti-histamines), metabolic/endocrine (diabetes mellitus, hypothyroidism, hypercalcemia, and pregnancy), and neurogenic (multiple sclerosis, Parkinson's disease, cerebral tumors, and Hirschsprung's disease). Other possible causes include irritable bowel syndrome, inadequate dietary fiber, and psychosocial problems. Pelvic floor outlet obstruction is a functional disorder of evacuation involving the external anal sphincter and pelvic floor voluntary musculature in which the muscles contract, rather than relax. This results in the anal canal being kept tightly closed during straining at attempted defecation. Biofeedback has been used successfully to teach patients with this disorder to relax the sphincter and pelvic floor musculature.

### **Migraine and Tension-type Headache**

It is estimated that 50 million Americans suffer from headache. It is now generally accepted that about 1 in 8 adults in the developed countries has migraine headaches. Women are affected 2 to 3 times more than men. This disorder predominantly affects young adults and the peak incidence is between the age of 25 and 34. There are 2 major types of migraine headaches: (1) migraine with aura (classical migraine) which accounts for 15 to 18 % of all migraine episodes, and (2) migraine without aura (common migraine) which accounts for 80 % of all migraine attacks. Some individuals suffer from both types of migraine at different times. The treatment of choice for frequent migraine sufferers is usually pharmacologic prophylaxis. Avoidance strategies (loud noises flashing lights, stress and certain foods) also constitute a very important first line approach in managing migraine. Biofeedback training with or without relaxation techniques have also been shown to be effective in treating migraine and tension headache. In particular, thermal biofeedback training has been shown to be effective in treating migraine headache. This technique teaches patients to increase the temperature of their fingers. Supposedly, dilatation of the peripheral blood vessels in the hand is associated with reduced blood flow in the regions of the supra-orbital and superficial temporal arteries, although the exact mechanism by which thermal

biofeedback improves migraine headaches is still unclear. For the management of tension headache, EMG feedback has been employed primarily. Moreover, it has been shown that the combination of thermal and EMG biofeedback has been effective in the control of migraine, tension, and mixed migraine and tension headache. Furthermore, it has been reported that relaxation techniques can produce improvements in headache. Available evidence indicates that biofeedback techniques (thermal, EMG, and temporal blood volume pulse biofeedback), with or without other behavioral therapies (relaxation and cognitive training), are safe and effective methods for the treatment of migraine and tension headache. This therapeutic modality has no side effects and does not preclude other options. Unlike migraine and tension headache, there is a lack of published data concerning the safety and effectiveness of biofeedback in the management of cluster headache. Before participating in a biofeedback program, patients should be examined by a physician to ensure that their headaches are not due to pathological conditions such as hematomas, aneurysm, brain tumors, brain edema, or diseases of the eye, ear and sinus. First line approaches, including avoidance of precipitating stimuli and pharmacologic prophylaxis, should have been tried and failed.

### **Neuromuscular Rehabilitation**

Typically stroke rehabilitation includes various combinations of range of motion and muscle strengthening exercises, gait and mobility training, and compensatory techniques. Other therapies include neurodevelopmental based methods in which the treatment incorporates neuromuscular re-education techniques where biofeedback may be employed. Among biofeedback techniques employed in neuromuscular rehabilitation, EMG biofeedback is the most common one. It is often utilized by stroke patients for facilitation of contraction (strength) and relaxation of spasticity (inhibition). Electromyographic biofeedback has also been used to treat patients with spasmodic torticollis and patients with muscular atrophy resulting from surgery. The goals of EMG biofeedback in neuromuscular rehabilitation include relaxation of muscles or recruitment of muscles. Relaxation of muscles is performed where muscles are either trained to relax as a consequence of hyperactivity that may be stress or work related or as a result of spasticity caused by central nervous system dysfunction. Recruitment of muscles is to facilitate increased motor unit output for movement generation or strength. This is most commonly used when muscles have been weakened or inhibited as a result of injury, immobilization or surgical procedure of a limb/joint.

The majority of biofeedback research has focused on the effects of biofeedback therapy in the treatment of upper limb and lower limb motor deficits in neurological disorders (e.g. stroke). Traditionally biofeedback is presented to the patient and the clinician via visual displays, acoustic or vibrotactile feedback. A recent development in rehabilitation is exercising in a gaming or virtual reality (VR) environment, thus providing a novel form of immersive biofeedback. With VR the measured patient activity is fed back via graphical or audiovisual animations providing a realistic impression to the patient

## **LITERATURE REVIEW**

### **Urinary Incontinence**

Pelvic floor muscle training is an established treatment option for urinary incontinence. Bladder training, changes in fluid intake, pharmacotherapy and surgical intervention may also be indicated based on the type of incontinence. Biofeedback is an established treatment modality for children and adults with stress, urge, mixed or overflow urinary incontinence that is unresponsive to other nonpharmacologic modalities such as bladder training and/or pelvic floor muscle training. Biofeedback may enhance awareness of body functions and assist the individual in learning muscle strengthening pelvic floor exercises. There are several proposed methods of biofeedback which may be employed for the treatment of urinary incontinence including: vaginal cones, perineometers and electromyographic (EMG) systems (Holroyd-Leduc, et al., 2008; Sham liyan, et al., 2008; Payne, 2007). The published peer-reviewed scientific literature includes systematic reviews, randomized controlled trials, and case series that have reported an improvement in urinary incontinence for up to two years following biofeedback (Fitz, et al., 2012; Herderschee, et al., 2011; Desantis, et al., 2011; Porena, et al., 2000; Burgio, et al., 2002; Herbison, et al., 2013; Hunter, et al., 2004; Yabci, et al., 2005; Dannecker, et al., 2005; Burgio, et al., 2006; Klijn, et al., 2006). In their guideline on the management of urinary incontinence in women, NICE (Sept 2015) stated that perineometry or pelvic floor electromyography as biofeedback should not be used as a routine part of pelvic floor muscle training, but biofeedback should be considered in women who cannot actively contract pelvic floor muscles in order to aid motivation and adherence to therapy. In their guideline on the management of urinary incontinence in women, NICE (Sept 2015) stated that perineometry or pelvic floor electromyography as biofeedback should not be used as a routine part of pelvic floor muscle training, but biofeedback should be considered in women who cannot actively contract pelvic floor muscles in order to aid motivation and adherence to therapy. The 2017 American Urological Society's (AUS) guidelines on the



management of surgical treatment of female stress urinary incontinence (SUI) recommends that physicians counsel patients with stress urinary incontinence or stress-predominant mixed urinary incontinence who wish to undergo treatment. Counseling should include available treatment options including pelvic muscle floor training with or without biofeedback.

Hagen et al. (2020) assessed the effectiveness of pelvic floor muscle training (PFMT) plus electromyographic biofeedback or PFMT alone for stress or mixed urinary incontinence in women. Six hundred women aged 18 and older, newly presenting with stress or mixed urinary incontinence between February 2014 and July 2016 were included in the study: 300 were randomized to PFMT plus electromyographic biofeedback and 300 to PFMT alone. Participants in both groups were offered six appointments with a continence therapist over 16 weeks. Participants in the biofeedback PFMT group received supervised PFMT and a home PFMT program, incorporating electromyographic biofeedback during clinic appointments and at home. The PFMT group received supervised PFMT and a home PFMT program. PFMT programs were progressed over the appointments. Main outcome measures: The primary outcome was self-reported severity of urinary incontinence (International Consultation on Incontinence Questionnaire-urinary incontinence short form (ICIQ-UI SF), range 0 to 21, higher scores indicating greater severity) at 24 months. Secondary outcomes were cure or improvement, other pelvic floor symptoms, condition specific quality of life, women's perception of improvement, pelvic floor muscle function, uptake of other urinary incontinence treatment, PFMT self-efficacy, adherence, intervention costs, and quality adjusted life years. Authors report that at 24 months, no evidence was found of any important difference in severity of urinary incontinence between PFMT plus electromyographic biofeedback and PFMT alone groups. Routine use of electromyographic biofeedback with PFMT should not be recommended. Other ways of maximizing the effects of PFMT should be investigated.

Wu et al. (2021) compared the efficacy of PFMT with and without EMG-BF on the cure and improvement rate, PFM strength, urinary incontinence score, and quality of sexual life for the treatment of stress urinary incontinence (SUI) or pelvic floor dysfunction (PFD). The outcomes were the cure and improvement rate, symptom-related score, pelvic floor muscle strength change, and sexual life quality. Twenty-one studies (comprising 1967 patients with EMG-BF + PFMT and 1898 with PFMT) were included. Compared with PFMT, EMG-BF + PFMT had benefits regarding the cure and improvement rate in SUI and in PFD, and in quality of life. There was limited evidence of publication bias. PFMT combined with EMG-BF achieves better outcomes than PFMT alone in SUI or PFD management. Baumann et al. (2021) analyzed the specific exercise effects of supervised versus unsupervised pelvic floor muscle exercise (PFME) and exercise volume on urinary incontinence status after radical prostatectomy in a systematic review and meta-analysis. The meta-analysis included 20 randomized controlled trials involving 2188 men ( $n = 1105$  in intervention groups;  $n = 1083$  in control groups). PFME versus no PFME had a beneficial effect on urinary incontinence remission at 3 months, 3-6 months, and more than 6 months post-surgery, with risk differences ranging from 12 to 25%. These effects were particularly evident for higher volume, supervised PFME in the first 6 months post-surgery. Additional biofeedback therapy appeared to be beneficial but only during the first 3 months post-surgery. Authors concluded that there is good evidence that the supervised PFME causes a decrease in short-term urinary incontinence rates. Unsupervised PFME has similar effects as no PFME in postoperative urinary incontinence. PFME programs should be implemented as an early rehabilitative measure to improve postoperative short-term urinary incontinence in patients with prostate cancer.

Jacobsen et al. (2021) evaluated the efficacy of physiotherapeutic intervention with biofeedback assisted PFMT in children with DV. Children referred with DV, unresponsive to standard urotherapy were included in this study. All children underwent biofeedback assisted PFMT sessions with a physiotherapist. Uroflowmetries and measurements of post-void residual (PVR) urine were performed before and after the treatment, and the following parameters were registered; daytime incontinence (DI), nocturnal enuresis (NE), constipation, faecal incontinence (FI), and recurrent urinary tract infections (UTI). Other concomitant treatments were noted. The primary outcomes were the resolution of DV evaluated by uroflow curve configuration and PVR. Secondary outcomes were the resolution of DI, NE and the reduction of recurrent UTIs. Forty-six children (mean age  $9.6 \pm 2.4$  years, 38 girls) were included in the analysis. The median period of treatment was  $9.0 \pm 8.5$  months (2-9 visits). Twenty-seven (59%) children responded to treatment according to one or both primary outcomes; uroflow configuration (50%) and PVR (28%). DI resolved in 12 (26%) children and 27 of the 32 children, who prior to the treatment had recurrent UTIs experienced no UTIs during the follow up period. The use of anticholinergics was a significant negative predictor for response to treatment. Biofeedback assisted PFMT can improve the symptoms in children with DV. When comparing to existing literature they found a less pronounced effect of the intervention. A possible explanation may be that the children enrolled in this study were recruited from a tertiary referral centre and were all refractory to standard urotherapy. Moreover, the difference in patient characteristics and treatment protocols

between different studies make direct comparisons of efficacy difficult. Authors concluded that physiotherapeutic intervention with biofeedback assisted PFMT seems to lead to better uroflow patterns in approximately 60% of cases in DV improving the uroflow curves and PVR, however improvement in uroflowmetry patterns is not necessarily reflected in the resolution of incontinence or UT symptoms. The use of anticholinergics seems to be a negative predictor for response to treatment.

Leonardo et al. (2022) compared biofeedback-assisted pelvic muscle floor training (PFMT) and pelvic electrical stimulation (ES) as an intervention group, with PFMT or bladder training (BT) as the control group, in women with an overactive bladder (OAB). Eight studies involving 562 patients (comprising 204 patients with biofeedback-assisted PFMT, 108 patients with pelvic ES, and 250 patients who received PFMT alone or BT and lifestyle recommendations only, as the control group) were included. The ES group showed significant differences in terms of changes to QoL, episodes of incontinence, and the number of participants cured or improved, while the biofeedback group resulted in nonsignificant changes in QoL, episodes of incontinence, and the number of participants cured or improved, both compared to the control group respectively. This meta-analysis shows that low-frequency pelvic ES appears to be sufficient and effective as an additional intervention for women with OAB in clinical practice according to improvements in the subjects' QoL and reduction of symptoms. Meanwhile, biofeedback-assisted PFMT does not appear to be a significant adjuvant for conservative OAB therapy.

Sam et al. (2022) compared the effectiveness of biofeedback-assisted pelvic floor muscle training (PFMT) and PFMT alone on voiding parameters in women with dysfunctional voiding (DV). The patients in group 1 (34 patients) were treated with biofeedback-assisted PFMT, and the patients in group 2 (34 patients) were treated with PFMT alone for 12 weeks. The 24-hour frequency, average voided volume, maximum urine flow rate (Qmax), average urine flow rate (Qave), post-void residual urine volume (PVR), and the validated Turkish Urogenital Distress Inventory (UDI-6) symptom scores were recorded before and after 12 weeks of treatment. At the end of treatment sessions, the Qmax and Qave values of the patients in group 1 were significantly higher than those in group 2, and the PVR in the patients in group 1 was significantly lower than those in group 2 ( $p=.026$ ,  $.043$ , and  $.023$ , respectively). The average UDI-6 symptom scores of the patients in group 1 were significantly lower than those in group 2 ( $p=.034$ ). Electromyography activity during voiding, in group 1 was significantly lower than in group 2 (41.2 vs. 64.7, respectively,  $p=.009$ ). Authors concluded that biofeedback-assisted PFMT is more effective than PFMT alone in improving clinical symptoms, uroflowmetry parameters, and EMG activity during voiding.

Todhunter et al. (2022) summarised Cochrane Reviews that assessed the effects of conservative interventions for treating UI in women. Authors included reviews that compared a conservative intervention with 'control' (which included placebo, no treatment or usual care), another conservative intervention or another active, but non-conservative, intervention. Primary outcomes of interest were patient-reported cure or improvement and condition-specific quality of life. Twenty-nine relevant Cochrane Reviews were included. Seven focused on physical therapies; five on education, behavioural and lifestyle advice; one on mechanical devices; one on acupuncture and one on yoga. Fourteen focused on non-conservative interventions but had a comparison with a conservative intervention. There were 112 unique trials (including 8975 women) that had primary outcome data included in at least one analysis. Stress urinary incontinence (14 reviews): Conservative intervention versus control: there was moderate or high certainty evidence that pelvic floor muscle training (PFMT), PFMT plus biofeedback and cones were more beneficial than control for curing or improving UI. Urgency urinary incontinence (five reviews): Conservative intervention versus control: there was moderate to high-certainty evidence demonstrating that PFMT plus feedback, PFMT plus biofeedback, electrical stimulation and bladder training were more beneficial than control for curing or improving UI. Authors concluded that there is high certainty that PFMT is more beneficial than control for all types of UI for outcomes of cure or improvement and quality of life.

Aouluni et al. (2022) sought to determine the effectiveness of pelvic floor muscle training (PFMT) with or without biofeedback or electrostimulation in reducing urinary incontinence and pelvic floor muscle contraction in non-pregnant women with urinary incontinence. Following the search, 15 RCTs were retrieved using the strict inclusion and exclusion criteria, assessing 2441 non-pregnant women with urinary incontinence. Of the 15 studies, 7 were low risk, 5 were medium risk, and 3 were high-risk studies. Of the 2441 patients, 970 were in PFMT, 69 were in extracorporeal magnetic innervation (ExMi) or with PFMT + BF, 30 were in electrostimulation (ES), 21 were in whole body vibration training (WBVT), 23 were in pelvic floor muscle + abdominal muscle therapy (PFM + AMT), 326 were in PFMT + biofeedback, 93 were in vaginal cones (VC), 362 were in PFMT + education, 318 were in education, and 229 were in control groups. The most often measures employed were pad tests, bladder diary, and questionnaire on the quality of life. Stress, urge and mixed urinary incontinence were studied. In all RCT, PFMT significantly reduced urinary incontinence, essentially SIU and MUI, when compared with the control group

before and after treatment. Overall, out of 997 PFMT or PFMT + education patients, 504 patients (50.5%) showed improvement in urinary incontinence, and 218 became continent (21.8%) (negative pad test). In total, 62% of patients significantly reduced their urinary incontinence or cured it and improved their pelvic floor muscle contraction. All other physiotherapist techniques also significantly reduced urinary leakages, e.g., vaginal cones, biofeedback, ExMI, and WBVT when compared with the control group. There were no significant differences between these methods in reducing the severity of urinary incontinence. Authors concluded that PFMT alone or with bio-feedback or electrostimulation was effective in reducing urinary incontinence and improving pelvic floor muscle contraction. PFMT when compared with other interventions such as bio-feedback, VC, and WBVT did not show significant differences but was superior to the control group.

Yang et al. (2023) analyzed the specific exercise effects of pelvic floor muscle training (PFMT) with or without biofeedback or electrical stimulation on urinary incontinence rehabilitation after radical prostatectomy. A total of 18 studies with 29,925 patients were included, all of which were of critically low methodological quality. Biofeedback therapy seemed to show additional benefits compared to PFMT alone; however, the adjunctive role of electrical stimulation remained more controversial due to the lack of strong evidence. Preoperative PFMT sometimes, but not always, showed the potential to improve urinary incontinence. PFMT with the guidance of a therapist could bring some benefits to the patient and was more acceptable to the patient, but consumed some medical resources. Authors concluded that PFMT has a good effect on improving post-radical prostatectomy incontinence in men, and biofeedback can have an additional beneficial effect on patients, especially in the short-term and medium-term. However, there is insufficient evidence to suggest that electrical stimulation is beneficial for patients with urinary incontinence.

Johnson et al. (2023) assessed the effects of conservative interventions for managing urinary incontinence after prostate surgery. Authors investigated the following key comparisons: PFMT plus biofeedback versus no treatment; sham treatment or verbal/written instructions; combinations of conservative treatments versus no treatment, sham treatment or verbal/written instructions; and electrical or magnetic stimulation versus no treatment, sham treatment or verbal/written instructions. They identified 25 studies including a total of 3079 participants. Twenty-three studies assessed men who had previously undergone radical prostatectomy or radical retropubic prostatectomy, while only one study assessed men who had undergone transurethral resection of the prostate. One study did not report on previous surgery. Most studies were at high risk of bias for at least one domain. The certainty of evidence assessed using GRADE was mixed. PFMT plus biofeedback versus no treatment, sham treatment or verbal/written instructions: Four studies reported on this comparison. PFMT plus biofeedback may result in greater subjective cure of incontinence from 6 to 12 months (1 study; n = 102; low-certainty evidence). However, men undertaking PFMT and biofeedback may be less likely to be objectively cured at from 6 to 12 months (2 studies; n = 269; low-certainty evidence). It is uncertain whether undertaking PFMT and biofeedback has an effect on surface or skin-related adverse events (1 study; n = 205; very low-certainty evidence) or muscle-related adverse events (1 study; n = 205; very low-certainty evidence). Condition-specific quality of life, participant adherence to the intervention and general quality of life were not reported by any study for this comparison. Combinations of conservative treatments versus no treatment, sham treatment or verbal/written instructions: Eleven studies assessed this comparison. Combinations of conservative treatments may lead to little difference in the number of men being subjectively cured or improved of incontinence between 6 and 12 months (2 studies; n = 788; low-certainty evidence; in absolute terms: no treatment or sham arm: 307 per 1000 and intervention arm: 297 per 1000). Combinations of conservative treatments probably lead to little difference in condition-specific quality of life (2 studies; n = 788; moderate-certainty evidence) and probably little difference in general quality of life between 6 and 12 months (2 studies; n = 742; moderate-certainty evidence). There is little difference between combinations of conservative treatments and control in terms of objective cure or improvement of incontinence between 6 and 12 months (2 studies; n = 565; high-certainty evidence). However, it is uncertain whether participant adherence to the intervention between 6 and 12 months is increased for those undertaking combinations of conservative treatments (2 studies; n = 763; very low-certainty evidence; in absolute terms: no intervention or sham arm: 172 per 1000 and intervention arm: 358 per 1000). There is probably no difference between combinations and control in terms of the number of men experiencing surface or skin-related adverse events (2 studies; n = 853; moderate-certainty evidence), but it is uncertain whether combinations of treatments lead to more men experiencing muscle-related adverse events (2 studies; n = 136; very low-certainty evidence; in absolute terms: 0 per 1000 for both arms). Authors concluded that despite a total of 25 trials, the value of conservative interventions for urinary incontinence following prostate surgery alone, or in combination, remains uncertain. Existing trials are typically small with methodological flaws. These issues are compounded by a lack of standardisation of the PFMT technique and marked variations in protocol concerning combinations of conservative treatments. Adverse events following conservative treatment are often poorly documented and incompletely

described. Hence, there is a need for large, high-quality, adequately powered, randomised control trials with robust methodology to address this subject.

Zhang et al. (2023) described and synthesized non-pharmacological and nonsurgical interventions for male urinary incontinence from the existing literature. A total of 4602 studies were identified, of which 87 studies were included. Approximately 78% were randomized controlled trials. More than 88% of the participants were men with prostate cancer. Exercising pelvic floor muscles 30 times per day for 12 weeks was the most frequently reported. Parameters of electrical stimulation were typically set up to 50 Hz and 300  $\mu$ s for frequency and width of pulse, respectively, and lasted for 15 min. Pure pelvic floor muscle training, Pilates, Yoga, whole body vibration, diaphragm/abdominal muscle training, micturition interruption exercise, acupuncture, and auriculotherapy showed positive effects on reducing urinary incontinence. Authors concluded that the findings suggested implementing pelvic floor muscle training alone before or after surgery can both prompt the recovery of continence in men after prostate cancer surgery. The decision to use biofeedback or electrical stimulation to enhance the therapeutic effect of pelvic floor muscle training should be approached with caution. More rigorous designed studies are needed to validate the effectiveness of Traditional Chinese Medicine techniques and diverse novel methods.

Höder et al. (2023) examined the scientific evidence regarding the impact of pelvic floor muscle training (PFMT) with feedback from a physiotherapist and/or biofeedback on urinary and anal incontinence in women during the first six months following vaginal delivery, compared to treatment without feedback in a systematic review. Eight studies were included, three of which showed a significant difference between groups, in favor of the intervention group that received pelvic floor muscle training with feedback from a physiotherapist and/or biofeedback. Due to the varying results and insufficient quality for the majority of the studies, the scientific basis was considered insufficient. Authors concluded that the scientific evidence for pelvic floor muscle training with feedback from a physiotherapist or biofeedback on postpartum urinary and anal incontinence compared to treatment without feedback is considered insufficient. Further research on the subject is needed.

Remes-Troche et al. (2023) presents the formulated recommendations in 35 statements. Fecal incontinence is known to be a frequent entity whose incidence increases as individuals age, but one that is under-recognized. The pathophysiology of incontinence is complex and multifactorial, and in most cases, there is more than one associated risk factor. Even though there is no diagnostic gold standard, the combination of tests that evaluate structure (endoanal ultrasound) and function (anorectal manometry) should be recommended in all cases. Treatment should also be multidisciplinary and general measures and drugs (lidamide, loperamide) are recommended, as well as non-pharmacologic interventions, such as biofeedback therapy, in selected cases. Likewise, surgical treatment should be offered to selected patients and performed by experts.

Khondker et al. (2024) sought to determine the effect of secondary management strategies in addition to urotherapy on bowel bladder dysfunction outcomes. In this systematic review and meta-analysis of 18 studies and 1228 children, secondary management strategies (home-based education, biofeedback, and physical therapy) were associated with reduced symptom burden, fewer recurrent urinary tract infections, and improved uroflowmetry findings than children treated solely with urotherapy for conservative management. Authors concluded that although there is significant reporting heterogeneity, secondary conservative management strategies such as home education, biofeedback or cognitive behavioral therapy, and physiotherapy-based education are associated with less urinary incontinence, fewer infections, and fewer abnormal uroflowmetry findings.

In an updated Cochrane Review, Fernandes et al. (2025) assessed the effects of PFMT with feedback or biofeedback, or both, for UI in women. They included only randomized controlled trials (RCTs), cluster-RCTs and quasi-RCTs in women with UI. They excluded studies that recruited women with neurological conditions, who were pregnant or less than six months postpartum. Eligible studies made one of the following comparisons: PFMT plus feedback versus PFMT alone, PFMT plus biofeedback versus PFMT alone, PFMT plus feedback or biofeedback versus PFMT alone, PFMT plus feedback versus PFMT plus biofeedback, and one type of biofeedback versus another. The primary outcome was lower urinary tract symptom-specific quality of life. Secondary outcomes were leakage episodes in 24 hours, leakage severity, subjective cure or improvement, satisfaction, and adverse events. Authors included 41 completed studies with 3483 women. Most (33 studies, 3031 women) investigated the effect of PFMT with biofeedback versus PFMT alone. Eleven studies were at low risk of bias overall, 27 at unclear risk of bias, and three at high risk. Only one study reported leakage severity, with no usable data. Comparison 1. PFMT with feedback versus PFMT alone: one eligible study reported no outcome of interest. Comparison 2. PFMT with biofeedback versus PFMT alone: there was little or no difference in incontinence quality of life (high-certainty evidence). Women randomized to biofeedback had 0.29 fewer leakage

episodes in 24 hours versus PFMT alone (moderate-certainty evidence), but this slight reduction in leakage episodes may not be clinically important. Women in biofeedback arms report that there is probably little to no difference in cure or improvement (moderate-certainty evidence) but may report greater satisfaction with treatment outcomes (low-certainty evidence). None of these outcomes were blinded. Eight studies (711 women) assessed severe adverse events but reported that there were no events. Comparison 3. PFMT with feedback or biofeedback versus PFMT alone: a single study contributed very-low certainty evidence regarding leakage episodes in 24 hours, subjective cure or improvement, and satisfaction. Comparison 4. PFMT with feedback versus PFMT with biofeedback: the evidence is very uncertain about any difference in effect between biofeedback versus feedback for incontinence-related quality of life. There were no data for subjective cure, improvement or satisfaction. One study measured adverse events and none were reported. Comparison 5. PFMT with biofeedback versus PFMT with another type of biofeedback: five studies assessed this comparison, with individual studies contributing data for separate outcomes. There was low- or very-low certainty evidence about the benefits of one type of biofeedback versus another for leakage episodes in 24 hours or subjective cure or improvement, respectively. One study reported adverse events from two of nine women receiving electromyography biofeedback versus six of 10 receiving pressure biofeedback. Authors concluded that PFMT with biofeedback results in little to no difference in incontinence quality of life. The addition of biofeedback to PFMT likely results in a small unimportant difference in leakage episodes in 24 hours, and likely little to no difference in patient-reported cure or improvement. Satisfaction may increase slightly for PFMT with biofeedback, based on low-certainty evidence. Five of the 33 studies in this comparison collected information about adverse events, and four reported none in either group. Adverse events reported by women using biofeedback seemed related to using a vaginal or rectal device (e.g. discomfort with device in place, vaginal discharge). The other comparisons had few, small studies, and low- to very low-certainty evidence for all outcomes. None of the studies reported any severe adverse events.

### **Fecal Incontinence**

Biofeedback has been proposed for the treatment of fecal incontinence, and overall, results from systematic reviews and randomized controlled trials reported that biofeedback may help improve this condition in certain patients. However, studies primarily include small heterogeneous patient populations and diagnosis; short-term follow-up, and various biofeedback regimens and methods. Patient selection criteria with appropriate types of biofeedback regimens have not been established. In the guideline on the management of fecal incontinence, NICE (2007) stated that adults who have persistent fecal incontinence after initial management should be considered for special continence services including biofeedback. Due to the limited evidence, biofeedback is not recommended as a first line therapy. Brazzelli et al. (2011) conducted a systematic review of randomized and quasi-randomized controlled trials to assess the effectiveness of behavior and/or cognitive interventions, including biofeedback, for the treatment of children with fecal incontinence. Twenty-one trials (n=1371) met inclusion criteria. Follow-ups ranged from 4–24 months with two trials reporting no follow-up following cessation of treatment. Combined results of nine trials showed higher rates of persistent symptoms of fecal incontinence for up to 12 months when biofeedback was added to conventional treatment (e.g., laxatives, toilet training, dietary advice, behavior modification). Based on this data, the authors concluded that there was “no evidence” that biofeedback training added any benefit to conventional therapy for the management of functional fecal incontinence nor was there enough data to assess the effectiveness of biofeedback for the management of organic fecal incontinence in children. Norton and Cody (2012) conducted a systematic review of randomized and quasi-randomized controlled trial to evaluate biofeedback and/or anal sphincter exercises for the treatment of fecal incontinence in adults. Twenty-one studies (n=1525) met inclusion criteria. Two biofeedback studies reported follow-ups at nine months and five studies reported follow-ups at one year, but most studies reported no follow-up following cessation of treatment. The authors stated that they found no evidence that biofeedback provided any benefit over any other treatment (e.g., dietary modification, bulking agents, pelvic floor exercises) for fecal incontinence. Evidence on patient selection criteria is lacking. Overall, the limited number of studies with methodological weaknesses, including incomplete outcome data, did not allow for definitive assessment of the role of biofeedback in the treatment of adults with fecal incontinence.

Vonthein et al. (2013) conducted a systematic review of randomized controlled trials to evaluate the effectiveness of biofeedback (BF) and electrical stimulation (ES) for the treatment of fecal incontinence. Included studies evaluated BF, ES, BF plus ES, and/or pelvic floor exercises as a second-line therapy in adults who had no obvious need for surgery. The included studies also had to report patient-related outcomes (i.e., remission, response, and/or disease-related quality of life). Thirteen trials met inclusion criteria. In 12 trials, at least one study group received biofeedback typically in combination with ES or another modality. One study compared BF alone vs. ES alone and reported no significant differences in FI in either group following treatment. Two studies reported a significant improvement in the FI severity index, number of days with FI, anal squeeze and/or quality of life.

However, the majority of studies reported no significant difference with the addition of biofeedback. The authors noted that BF seemed to be better than no BF and concluded that ES plus BF seemed to be the most effective treatment. Limitations of the studies investigating biofeedback for fecal incontinence included: small patient populations; heterogeneous populations (e.g., obstetrical trauma, elderly women); short-term follow-ups, conflicting outcomes, and missing data. The Italian Society of Colorectal Surgery (SICCR) and the Italian Association of Hospital Gastroenterologists (AIGO) joint committee developed a 2015 consensus statement for the treatment of fecal incontinence (FI). In the discussion of rehabilitative treatment for functional FI, the Committee reported that randomized controlled studies sustain the use of biofeedback. According to SICCR, a few studies suggested that adding biofeedback does not enhance the outcome of conservative management while other studies suggested that biofeedback and pelvic floor exercises be considered as a first-line option for patients who fail treatment with dietary changes, devices or drugs. Since there are no side effects, failure of biofeedback would not affect decisions regarding future therapy. Biofeedback with kinesitherapy (movement therapy) may also be a useful treatment. One study suggested biofeedback can be helpful after sphincteroplasty. The authors noted that techniques used for biofeedback and other modalities vary greatly and results of studies are not comparable (SICCR, 2015). Limitations of the studies evaluating biofeedback for the treatment of FI included: small, heterogeneous patient populations; heterogeneity of diagnosis, biofeedback methods and outcome measures; inconsistent statistically improved outcomes (e.g., embarrassment score, severity of FI, number of FI occurrences) across studies; lack of a control group; and conflicting outcomes. In some studies outcomes were not generalizable due to the diagnosis (e.g., obstetrical trauma).

The American Society of Colon and Rectal Surgeons (ASCRS) (2015) stated that biofeedback should be considered as an initial treatment of fecal incontinence in motivated patients with some preserved voluntary sphincter contraction. ASCRS noted that the benefits are variable and standard care (e.g. advice and education) alone have been shown to be as effective as biofeedback therapy. The recommendation is based on moderate-quality evidence and ASCRS noted that larger, well-designed studies are needed to make any definitive conclusions. In their 2015 guidelines for the efficacy of biofeedback for anorectal disorders, the American Neurogastroenterology and Motility Society (ANMS) and the European Society of Neurogastroenterology and Motility (ESNM) recommended biofeedback for the short- and long-term treatment of fecal incontinence for patients who have not responded to conservative medical treatment (e.g., antidiarrheals, fiber supplements). The guideline noted that treatment success is best defined as a 50% reduction in episodes of fecal incontinence, which has not been used in clinical trials. Other publications support this (Patcharatrakul and Rao, 2018; Rao et al., 2016). The Societies recommendation was based on nonrandomized studies rated as fair evidence and they noted that further research is needed to standardize the treatment protocols and the training of biofeedback therapists (Rao, et al., 2015). Overall, studies investigating the effectiveness of biofeedback for fecal incontinence included small, heterogeneous patient populations and treatment regimens with short-term follow-ups. Biofeedback was used as an adjunctive therapy with various modalities. Outcomes were conflicting and several studies reported that no significant differences were seen with biofeedback. Because some studies included defined subpopulations (e.g., females with impaired fecal incontinence after obstetric anal sphincter injury) outcomes were not generalizable.

The Agency for Healthcare Research and Quality (AHRQ) conducted a 2016 comparative effectiveness review on treatments for fecal incontinence (FI) in adults. Thirteen randomized controlled trials examined pelvic floor muscle training (PFMT) and PFMT with biofeedback (PFMT-BF). Enrolled adults were mostly female with mixed FI etiologies. Meta-analysis was not possible due to the numerous outcomes that were used. PFMT-BF was the most frequently studied intervention. Outcomes included the frequency and severity of FI, quality of life and perceived improvement. AHRQ found that the evidence was insufficient to support PFMT-BF vs. standard care (e.g., dietary fiber, stool-modifying drugs, and/or advice). Low-strength evidence showed that PFMT-BF with electrostimulation was no more effective than PFMT-BF alone on FI severity and FI quality of life over two to three months. Although PFMT-BF showed improvement in FI outcomes, the improvements were not significantly different from the comparison groups. AHRQ noted that future studies should focus on longer term effects and attempt to identify subgroups of adults by FI etiology that might benefit from specific interventions.

Li et al. (2022) systematically reviewed and synthesized the evidence on the effectiveness of biofeedback therapy in patients with bowel dysfunction following rectal cancer surgery. Randomized controlled trials (RCTs), cohort studies, and case series studies were included for adults with bowel dysfunction following rectal cancer surgery. All participants received an intervention of biofeedback treatment. Any outcomes that can evaluate the patient's bowel function were the primary research endpoint, while the quality of life was the second endpoint. Key findings included significant improvements in bowel function as well as health-related quality of life after biofeedback

therapy. Authors concluded that although biofeedback therapy may improve intestinal function and quality of life as well as anal function after surgery, patient satisfaction is still unclear. Due to the scarcity of data, good-quality research is required to delve deeper.

Pun et al. (2024) investigated the effectiveness of physiotherapy interventions compared to control conditions on fecal incontinence (FI) and quality of life (QoL) following colorectal surgery. Ten trials were included. Meta-analysis revealed statistically significant improvements in lifestyle, coping behavior, and embarrassment components of QoL among individuals receiving pelvic floor muscle training (PFMT) compared with those receiving usual care (UC). Meta-analysis showed biofeedback to be significantly more effective than UC in enhancing anal resting pressure (ARP), maximum squeeze pressure (MSP), and rectal resting pressure (RRP). Meta-analysis also found PFMT combined with biofeedback to be significantly more effective than PFMT alone for ARP, MSP, and RRP. Authors concluded that PFMT combined with biofeedback was more effective than PFMT alone, but both interventions delivered alone were superior to UC. Future studies remain necessary to optimize and standardize the PFMT parameters for improving QoL among individuals who experience FI following CRC surgery.

### **Levator Ani Syndrome**

In their 2015 guidelines for the efficacy of biofeedback for anorectal disorders, the American Neurogastroenterology and Motility Society (ANMS) and the European Society of Neurogastroenterology and Motility (ESNM) recommended biofeedback may be useful in the short-term treatment of Levator Ani Syndrome with dyssynergic defecation (Level II, Grade B) (Rao, et al., 2015). Reports of biofeedback treatment for chronic functional anorectal pain have shown inconsistent results, and most of these were small and uncontrolled (46). However, a RCT of 157 well-characterized patients with LAS compared three treatments: biofeedback to teach pelvic floor muscle relaxation, electrogalvanic stimulation (EGS) to relax the pelvic floor, and digital massage of the levator muscles (Chiarioni et al., 2010). The primary outcome measure was the subjects' report of adequate pain relief. Key to the interpretation of the study was an a priori decision to test for tenderness when traction was applied to the levator ani muscles during digital rectal examination, and patients were stratified into the three treatment arms based on the presence or absence of tenderness. Among patients with tenderness on physical examination, adequate relief was reported by 87% with biofeedback, 45% with EGS and 22% with digital massage. However, none of these three treatments were effective in patients who did not report tenderness on physical examination (Chiarioni et al., 2010). The mixed results reported in previous biofeedback studies most likely were a consequence of failure to stratify patients based on the presence or absence of levator ani tenderness. Other publications also support this (Patcharatrakul and Rao, 2018; Rao et al., 2016). Biofeedback therapy has also been used to treat Solitary Rectal Ulcer Syndrome (SRUS) in open, short-term, small sized (less than 20 patients) studies. Inclusion criteria, physiological investigations and outcome parameters were variable. Biofeedback therapy was associated with symptom improvement in at least two thirds of patients with some histological improvement. Most notably, the highest successful outcome was reported when SRUS was associated with dyssynergic defecation (DD) (Rao et al., 2015). Narayanan et al. (2019) authored a review to update practitioners on recent advances and to identify practical obstacles to providing biofeedback therapy. Authors summarized recent findings: the efficacy and safety of biofeedback therapy evaluated in defecatory disorders, fecal incontinence, and levator ani syndrome. They note that based on literature, biofeedback therapy is effective for managing defecatory disorders, fecal incontinence, and levator ani syndrome. Biofeedback therapy is recommended for patients with fecal incontinence who do not respond to conservative management. A subset of patients with levator ani syndrome who have dyssynergic defecation are more likely to respond to biofeedback therapy.

### **Chronic Constipation**

The evidence in the published peer-reviewed scientific literature supports the use of biofeedback for the treatment of constipation in adults. Significant improvements in constipation with biofeedback have been reported in systematic reviews, meta-analysis and randomized controlled trials (Skardoon et al., 2017; Woodward et al., 2014; Enck, et al., 2009; Koh, et al., 2008; Heyman, et al., 2007; Rao, et al., 2007; Chiarioni, et al., 2006; Heyman, et al., 2003). Biofeedback for the treatment of constipation in children is not well established and has not been proven to add additional benefit to established conventional therapy (Brazzelli, et al. 2006; Brazzelli, et al. 2004). The 2010 guideline (updated 2017) on the management of constipation in children and young adults by the National Institute for Health and Clinical Excellence (NICE) (United Kingdom) stated that biofeedback should not be used for ongoing treatment in children and young people with idiopathic constipation. Meta-analysis showed no improvement in outcomes when conventional treatment (e.g., use of laxatives, advice on a high-fiber diet, attempting defecation after meals) was compared to conventional treatment plus biofeedback. In a 2014 evidence-based guideline on the evaluation and treatment of functional constipation in infants and children, the North

American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN) and the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) concluded that the evidence did not support the use of behavioral therapy or biofeedback in the treatment of childhood constipation (Tabbers, et al., 2014).

The 2013 American Gastroenterological Association's (AGA) position statement on constipation for adults stated that biofeedback improves symptoms in more than 70% of patients with defecatory disorders. Biofeedback can be used to train patients to relax their pelvic floor muscles during straining and to correlate relaxation and pushing to achieve defecation. The success of the therapy depends on the motivation of the patient and therapist, frequency and intensity of the retraining, and involvement of behavioral psychologist and dieticians. AGA "strongly recommends" "based on high quality evidence" that biofeedback be used rather than laxatives for defecatory disorders which are primarily characterized by impaired rectal evacuation from inadequate rectal propulsive forces and/or increased resistance to evacuation. In practice guidelines on the management of constipation, the American Society of Colon and Rectal Surgeons (ASCRS) (2016) states that in general, biofeedback should be used to treat slow-transit constipation and pelvic floor dyssynergia before subtotal colectomy. ASCRS recommended biofeedback as a first-line treatment option for patients with constipation due to symptomatic pelvic floor dyssynergia.

The American Neurogastroenterology and Motility Society (ANMS) and the European Society of Neurogastroenterology and Motility (ESNM) (Rao, et al., 2015) provided evidence-based recommendations on the efficacy of biofeedback for anorectal disorders. The Societies conducted a review of the literature and used the U.S. Preventive Services Task Force evidence criteria to grade the recommendations. The Societies' recommendations included the following:

- Biofeedback is recommended for the short-term and long-term treatment of constipation with dyssynergic defecation (Level I, Grade A: evidence from at least one properly randomized controlled trial; good evidence; strongly recommends that clinicians routinely provide).
- Biofeedback may be useful for the short-term treatment of Levator Ani Syndrome with dyssynergic defecation (level II, Grade B: nonrandomized studies; fair evidence; recommends that clinicians routinely provide) and solitary rectal ulcer syndrome with dyssynergic defecation (level III, Grade C; opinions of authorities, based on clinical experience, descriptive studies and case reports or reports of expert committees; fair evidence; makes no recommendation).
- Biofeedback therapy is not recommended for the routine treatment of children with functional constipation, with or without overflow fecal incontinence. (Level 1, Grade D; evidence from at least one properly randomized controlled trial; recommends against its use).

The French National Society of Coloproctology (Vitton et al., 2018) offers clinical practice recommendations for chronic constipation on the basis of the data in the current literature, including those on recently developed treatments. Most are noninvasive, and the main concepts include the following: stimulant laxatives are now considered safe drugs and can be more easily prescribed as a second-line treatment; biofeedback therapy remains the gold standard for the treatment of anorectal dyssynergia that is resistant to medical treatment. Moore and Young (2020) assessed the effectiveness of biofeedback therapy for dyssynergic defaecation using global clinical improvement as the primary outcome, and resolution of the dyssynergic pattern on anorectal physiology and quality of life as secondary outcomes in a systematic review and meta-analysis. Eleven trials including 725 participants were included in the narrative review. Sixty-three percent of patients treated with biofeedback reported clinical improvement. Six studies included in the meta-analysis showed biofeedback superior to non-biofeedback therapy for the primary outcome. Heterogeneity between trials and overall risk of bias was high. Authors concluded that biofeedback therapy is recommended for patients referred to tertiary units with dyssynergic defaecation who fail conservative therapy. In a paper on biofeedback for defecatory disorders, Hite and Curran (2021) state that biofeedback has demonstrated efficacy in the treatment of chronic constipation with dyssynergic defecation, fecal incontinence, and low anterior resection syndrome. Evidence for the use of biofeedback in levator ani syndrome is conflicting. In comparing biofeedback to pelvic floor muscle training alone, studies suggest that biofeedback is superior therapy.

Wegh et al. (2021) evaluated the effectiveness and safety of non-pharmacological interventions for the treatment of childhood functional constipation. 52 RCTs were included with 4668 children, aged between 2 weeks and 18 years, of whom 47% were females. Studied interventions comprised of gut microbiome-directed interventions, other dietary interventions, oral supplements, pelvic floor-directed interventions, electrical stimulation, dry cupping, and massage therapy. An overall high risk of bias was found across the majority of



studies. Meta-analyses for treatment success and/or defecation frequency, including 20 RCTs, showed abdominal electrical stimulation (n=3), Cassia Fistula emulsion (n=2), and a cow's milk exclusion diet (n=2 in a subpopulation with constipation as a possible manifestation of cow's milk allergy) may be effective. Evidence from RCTs not included in the meta-analyses, indicated that some prebiotic and fiber mixtures, Chinese herbal medicine (Xiao'er Biantong granules), and abdominal massage are promising therapies. In contrast, studies showed no benefit for the use of probiotics, synbiotics, an increase in water intake, dry cupping, or additional biofeedback or behavioral therapy. We found no RCTs on physical movement or acupuncture. Authors concluded that more well-designed high quality RCTs concerning non-pharmacological treatments for children with functional constipation are needed before changes in current guidelines are indicated.

Sadeghi et al. (2023) completed a comprehensive review on diagnosis and management of dyssynergic defecation (DD). Relative to biofeedback training (BFT), studies have clearly shown that BFT is more effective than dietary modification, laxatives, diazepam, muscle relaxants, placebo, and sham biofeedback, has longer persistency and no adverse effect. They concluded that biofeedback therapy could improve bowel movements, stool consistency, straining, sensation of incomplete evacuation, quality of life, and para-clinical features of DD in diagnostic testing.

### **Migraine and Tension-type Headache**

Biofeedback is a standard treatment option for migraine and tension headaches. Systematic reviews and randomized controlled trials have reported that biofeedback is effective in reducing the severity and frequency of these headaches in adults and children (Vasudeva, et al., 2003; Eccleston, et al., 2004; Kaushik, et al., 2005; Nestoriuc and Martin 2007). After conducting a meta-analysis of 55 randomized controlled trials, including 1718 patients assigned to biofeedback and 511 patients assigned to controls, Nestoriuc and Martin (2007) stated that biofeedback could be recommended as an evidence-based behavioral treatment option for the prevention of migraine.

Martino et al. (2023) presented an up-to-date evaluation of the efficacy of EMG-biofeedback (EMG-BFB) for primary headaches and to address possible mediators of outcome. A total of 3059 articles were identified through the database searches. 29 articles, involving 1342 participants, met the inclusion criteria for the systematic review; of them, 4 were included in the meta-analysis. Ten studies reported a significant improvement in the EMG-BFB group with respect to the control group. Meta-analyses show a reduction in the intensity of attacks in patients subjected to EMG-BFB based on 293 patients). Authors concluded that EMG-BFB represents a non-pharmacological approach to headache treatment as shown via qualitative synthesis, despite not impressive results, this technique can be particularly useful in pediatric or in adult patients who cannot undergo drug therapies. Quantitative synthesis revealed a promising effect in the intensity of headaches attacks. Moreover, no significant effect was found about the effectiveness of EMG-BFB in the reduction of frequency and durations of headache attacks.

Treadwell et al. (2025) synthesized evidence on the benefits and harms of behavioral interventions for migraine prevention in children and adults. For adults, they included 50 trials (77 publications, N = 6024 adults). Most interventions were multicomponent (e.g., cognitive behavioral therapy [CBT], biofeedback, relaxation training, mindfulness-based therapies, and/or education). Most trials were at high risk of bias, primarily due to possible measurement bias and incomplete data. For adults, authors found that any of three components (CBT, relaxation training, mindfulness-based therapies) may reduce migraine/headache attack frequency (strength of evidence (SOE): low). Education alone that targets behavior may improve migraine-related disability (SOE: low). For three other interventions (biofeedback, acceptance and commitment therapy, and hypnotherapy), evidence was insufficient to permit conclusions. They also found that mindfulness-based therapies may reduce migraine disability more than education, and relaxation + education may improve migraine-related quality of life more than propranolol (SOE: low). For children/adolescents, 13 trials were included (16 publications, N = 1444 children), but the evidence was only sufficient to conclude that CBT + biofeedback + relaxation training may reduce migraine attack frequency and disability more than education alone (SOE: low). Results suggest that for adults, CBT, relaxation training, and mindfulness-based therapies may each reduce the frequency of migraine/headache attacks, and education alone may reduce disability. For children/adolescents, CBT + biofeedback + relaxation training may reduce migraine attack frequency and disability more than education alone. Evidence consisted primarily of underpowered trials of multicomponent interventions compared with various types of control groups. Limitations include semantic inconsistencies in the literature since 1975, differential usage of treatment components, expectation effects for subjectively reported outcomes, incomplete data, and unclear dosing effects. Future research should enroll children and adolescents, standardize intervention components when possible to

improve reproducibility, consider smart study designs and personalized therapies based on individual characteristics, use comparison groups that control for expectation, which is a known challenge in behavioral trials, enroll and retain larger samples, study emerging digital and telehealth modes of care delivery, improve the completeness of data collection, and establish or update clinical trial conduct and reporting guidelines that are appropriate for the conduct of studies of behavioral therapies.

### **Neuromuscular Rehabilitation**

There is sufficient evidence that EMG biofeedback is safe and effective for neuromuscular rehabilitation in patients who suffered from strokes (Giggins et al., 2013; Stanton et al., 2017). However, there is insufficient evidence that EMG biofeedback is effective as a rehabilitation modality for patients with spinal cord injury and in patients with spasmodic torticollis (Giggins et al., 2013). Additionally, although there is limited evidence that EMG biofeedback is effective in enhancing the return to full active knee extension and peak torque of the quadriceps femoris muscle following knee surgeries, there is little data on how these improvements translate clinically into improved functional outcomes (Giggins et al., 2013). For patients to potentially benefit from EMG biofeedback, they need to have some volitional muscle activity but remain disabled with no receptive aphasia. And biofeedback should be used when other standard forms of therapy have failed.

Pollock et al. (2003) conducted a systematic review on the recovery of postural control and lower limb function following stroke. The objective was to determine if outcomes were different if the physiotherapy treatment was based on orthopedic, neurophysiology, motor learning principles or a mixture of these modalities. The review included randomized or quasi-randomized controlled trials with interventions of physiotherapies, including biofeedback. Outcomes measured the degree of disability and motor impairment. Eighteen studies were categorized as EMG biofeedback and fifteen studies as positional biofeedback. The authors concluded that there was insufficient evidence to determine if one method was more effective than the other. Woodford and Price (2007) conducted a meta-analysis of 13 studies (n=269) on the use of electromyographic biofeedback (EMG-BFB) for the recovery of motor function following a stroke. The analysis included randomized controlled trials and quasi-randomized controlled trials that compared physiotherapy or exercises or physical therapy alone to these treatment modalities plus EMG/EMG-BFB. There were variations in the time from stroke to randomization (35 to 1140 days), and the length of the studies ranged from four to 16 weeks. Small sample sizes (n=10–40) were also a limitation of the studies. Outcome criteria included changes in motor strength, range of motion, stride length, gait speed, functional ability and gait quality score. Overall, the data did not demonstrate a positive effect on the outcomes. The authors concluded that EMG-BFB did “not appear to have a positive benefit for recovery after stroke,” and it could not be recommended as a routine treatment modality. Tate and Milner (2010) conducted a systematic review of randomized controlled trials (n=7) to evaluate the effectiveness of biofeedback in treating gait abnormalities. The types of biofeedback included real-time kinematic, temporospatial and kinetic. In five studies the patient population (n=105) was status-post stroke. One study included 42 patients with hip or knee replacement, hip fracture or amputation and one study included 28 patients status-post total hip replacement. There was a large range in the structure of the treatment protocol (e.g., treatment time, frequency, duration) and meta-analysis was not performed because of the wide variety of study designs, methodologies and outcome measures. Although some studies reported short-term improvement, long-term outcomes were not reported and whether or not improvements were maintained is unknown. The authors concluded that there was insufficient data to make a guideline recommendation for biofeedback for gait training.

Zijlstra et al. (2010) conducted a systematic review of randomized controlled trials (n=17) and comparative studies (n=4) to evaluate the effectiveness of biofeedback training for balance and/or mobility in older adults. Twelve studies included post-stroke patients, six included frail older adults in a care center and three studies included lower limb amputation and/or hip surgery. The biofeedback was visual and/or audio. The studies were determined to be of moderate quality with variations in analyses and outcomes. Due to the inability to perform quantitative analysis and the absence of large-scale randomized controlled trials, definitive conclusions could not be made. The addition of biofeedback during gait training did not seem to improve disability and mobility functioning. Doğan-Aslan et al. (2012) evaluated the effect of electromyographic biofeedback (EMG-BF) treatment on wrist flexor muscle spasticity, upper extremity motor function, and ability to perform activities of daily living in patients with hemiplegia following stroke. A total of 40 patients were enrolled and were randomly assigned to two groups: a group treated with EMG-BF (study group) and a untreated (control) group. Both groups participated in a hemiplegia rehabilitation program consisting of neurodevelopmental and conventional methods. In addition, the study group received 3 weeks of EMG-BF treatment, 5 times a week, for 20 minutes per session at hemiplegic side wrist flexors. Clinical findings were assessed before and after rehabilitation using the Ashworth scale (AS), Brunnstrom's stage (BS) of recovery for hemiplegic arm and hand, the upper extremity function test (UEFT), the

wrist and hand portion of the Fugl-Meyer scale (FMS), goniometric measurements of wrist extension, surface EMG potentials, and the Barthel Index (BI). There was no statistically significant difference between the two groups in terms of baseline measures. There also was no statistically significant difference in the pretreatment values between two groups. Authors noted statistically significant improvements posttreatment in the AS, BS, UEFT, goniometric measurements of wrist extension, and surface EMG potentials in the study group. They also noted statistically significant differences in the wrist and hand portion of the FMS and the BI in both groups, but with significantly greater improvements in the study group. Authors concluded that findings indicate a positive effect of EMG-BF treatment in conjunction with neurodevelopmental and conventional methods in hemiplegia rehabilitation.

Stanton et al. (2011) conducted a systematic review and meta-analysis of 22 randomized and quasi-randomized controlled trials to evaluate the effectiveness of biofeedback in enhancing lower-limb training for sitting, standing up, standing or walking following a stroke. Included clinical trials used various forms of biofeedback including any signal (position, EMG) via any sense (visual, auditor, tactile) during the practice of the whole activity. Based on pooled data from 17 trials (n=411) biofeedback improved lower limb activities compared to usual therapy or placebo in the short-term (i.e., one to five months following cessation of therapy). However, the authors noted that there was substantial heterogeneity of the low quality trials using any form of biofeedback; lack of blinding of subjects and therapists; possible small trial bias and selection bias based on intervention in the studies used for meta-analysis; and only half of the trials measured outcomes for any length of time following cessation of therapy. Well-designed randomized controlled trials with long-term results are needed to support the effectiveness of biofeedback in stroke patients. Stanton et al., (2017) completed on systematic review with meta-analysis to determine if biofeedback during the practice of lower limb activities after stroke is more effective than usual therapy in improving those activities. Outcome measures were activity measures congruent with the activity trained.

Eighteen trials including 429 participants met the inclusion criteria. The quality of the included trials was moderately high, with a mean PEDro score of 6.2 out of 10. Results demonstrated that biofeedback improved performance of activities more than usual therapy. Authors concluded that biofeedback is more effective than usual therapy in improving performance of activities. They also stated that further research is required to determine the long-term effect on learning and given that many biofeedback machines are relatively inexpensive, biofeedback could be utilised widely in clinical practice. Wattchow et al. (2018) investigated the therapeutic interventions reported in the research literature and synthesize their effectiveness in improving upper limb (UL) function in the first 4 weeks poststroke. A total of 104 trials (83 RCTs, 21 nonrandomized studies) were included (N=5225 participants). Evidence was found to support supplementary use of biofeedback and electrical stimulation. Authors concluded that use of mCIMT and task-specific training was supported, as was supplementary use of biofeedback and electrical simulation, within the acute phase poststroke.

Lirio-Romero et al. (2021) examined the effects of a 6-week surface electromyographic biofeedback intervention on the re-learning of upper extremity motor function in subjects with paretic upper extremity after stroke. Thirty-eight participants in the sub-acute post-stroke stage were recruited and randomly allocated into either the surface electromyographic biofeedback (sEMG-BFB) or sham biofeedback (BFB) groups. The sEMG-BFB group (n=19) received the intervention focused on re-learning scapulothoracic control during arm-reaching tasks involving shoulder abduction. The sham BFB group (n=19) received a sham intervention. In the short term, a 6-week sEMG-BFB intervention effectively improved paretic upper limb motor function. Future research is needed to determine if the sEMG-BFB intervention has any long-term effects.

Spencer et al. (2021) evaluated the state of the current evidence regarding the effectiveness of biofeedback for post-stroke gait training. Their overall goal was to determine whether gait biofeedback was effective at improving stroke gait deficits while also probing why and for whom gait biofeedback may be an efficacious treatment modality. Their literature review showed that the effects of gait biofeedback on post-stroke walking dysfunction are promising but are inconsistent in methodology and therefore results. There is a need for larger-sample studies that directly compare different feedback parameters, employ more uniform experimental designs, and evaluate characteristics of potential responders. However, as these uncertainties in existing literature are resolved, the application of gait biofeedback has potential to extend neurorehabilitation clinicians' cues to individuals with post-stroke gait deficits during ambulation in clinical, home, and community settings, thereby increasing the quantity and quality of skilled repetitions during task-oriented stepping training.

Balbinot et al. (2022) summarized the most common sEMG techniques used to address clinically relevant neurorehabilitation questions. Authors focused on the role of sEMG assessments in the clinical practice and

research studies on neurorehabilitation after spinal cord injury (SCI), and how sEMG reflects the changes observed with rehabilitation. Of 4522 references captured in the primary database searches, 100 references were selected and included in the scoping review. The main focus of the studies was on neurorehabilitation using sEMG biofeedback, brain stimulation, locomotor training, neuromuscular electrical stimulation (NMES), paired-pulse stimulation, pharmacology, posture and balance training, spinal cord stimulation, upper limb training, vibration, and photobiomodulation. Authors concluded that most studies employed sEMG amplitude to understand the effects of neurorehabilitation on muscle activation during volitional efforts or reduction of spontaneous muscle activity (e.g., spasms, spasticity, and hypertonia). Further studies are needed to understand the long-term reliability of sEMG amplitude, to circumvent normalization issues, and to provide a deeper physiological background to the different sEMG analyses. This scoping review reveals the potential of sEMG in exploring promising neurorehabilitation strategies following SCI and discusses the barriers limiting its widespread use in the clinic.

Li et al. (2023) evaluated the effect of different traditional Chinese and western medicine rehabilitation techniques on motor dysfunction after stroke using a network meta-analysis. Seventy-four randomized controlled trials involving nine rehabilitation techniques and 5128 patients were included. The results of network meta-analysis showed the following orders regarding improvement of the total scores of Fugl-Meyer Assessment, Action Research Arm Test, and Berg Balance Scale: biofeedback therapy > mirror therapy > repetitive transcranial magnetic stimulation > acupuncture therapy > transcranial direct current stimulation > Taichi > common therapy, virtual reality > transcranial direct current stimulation > repetitive transcranial magnetic stimulation > mirror therapy > common therapy, and acupuncture therapy > virtual reality > neuromuscular electrical stimulation > mirror therapy > common therapy > transcranial direct current stimulation, respectively. Authors concluded that biofeedback therapy had the best comprehensive effect, while virtual reality was the best intervention for improving the index of action research arm test and Fugl-Meyer Assessment-lower extremity. Acupuncture therapy improved lower limb balance function.

Tiryaki et al. (2023) investigated the effectiveness of a rehabilitation program with electromyographic biofeedback compared with the control group on patients with massive rotator cuff tear. Forty-six adults with massive rotator cuff tears, randomly assigned to 2 groups (23 electromyographic biofeedback group vs. 23 control group). The electromyographic biofeedback group (experimental group) performed the exercises under the guidance of electromyographic biofeedback, unlike the control group. All patients underwent a 45-minute training session a day, 3 times a week over a 6-wk duration, and followed up until 1-year. The outcome measures were American Shoulder and Elbow score, shoulder flexion strength, shoulder range of motion, Numeric Pain Rating Scale, and Global Rating of Change Scale. Compared with the control group, the electromyographic biofeedback group demonstrated a significant change in shoulder flexion strength and patient satisfaction from baseline to 6 wks (posttraining) and from baseline to 12-mo follow-up. There were significant improvements in within groups statistics for American Shoulder and Elbow score, shoulder flexion strength, shoulder range of motion, and Numeric Pain Rating Scale in both groups. Authors conclude that the results demonstrate that deltoid-focused structured rehabilitation program combined with electromyographic biofeedback can be used to increase shoulder flexion strength and patient satisfaction in conservative treatment of massive rotator cuff tear.

Wang et al. (2024) evaluated whether electromyographic biofeedback can improve upper and lower limb dysfunction in stroke patients. The analyses included 10 studies enrolling a total of 303 participants. Electromyographic biofeedback therapy can effectively improve limb function after stroke and in subgroup analyses, the effect sizes of short-term effect was significant, but the long-term was not. In addition, electromyographic biofeedback therapy can improve the active range of motion of shoulder and wrist joints after stroke. Authors concluded that in this meta-analysis, electromyographic biofeedback therapy intervention can improve upper and lower limb function in patients with stroke. Short-term (less than one month) improvement after electromyographic biofeedback therapy was supported, while evidence for long-term (more than one month) benefits was lacking. Range of motion in the glenohumeral and wrist joints were improved. Stronger evidence for individualized parameters, such as optimal treatment parameters and intervention period, is needed in the future.

In the VA/DoD Clinical Practice Guideline for Management of Stroke Rehabilitation updated in 2024, it is noted that there is insufficient evidence to recommend for or against biofeedback as an adjunct intervention to improve motor outcomes.

## **Other Conditions**

Biofeedback has been proposed as a treatment modality for numerous other conditions including: alcohol and drug abuse, anxiety disorders, asthma, autism spectrum disorders, cancer pain and symptoms, cardiovascular disease, cerebral palsy, acute and chronic back pain, chronic prostatitis, cystic fibrosis, epilepsy, fibromyalgia, functional dyspepsia, heart failure, hypertension, hyperhidrosis, knee osteoarthritis, labor pain, pervasive developmental disorders, posttraumatic stress disorder (PTSD), Raynaud's syndrome, recurrent urinary tract infection, reflex sympathetic dystrophy or complex regional pain syndrome, rheumatoid arthritis, spastic torticollis, temporomandibular disorders, tinnitus, type 2 diabetes mellitus, upper limb pain, vulvodynia and whiplash. However, the evidence in the published peer-reviewed scientific literature does not support the efficacy of biofeedback for the treatment of these conditions. Overall, there is a lack of randomized controlled trials using sufficient sample sizes, comparing biofeedback to established therapeutic modalities (e.g., pharmacotherapy, behavior therapy) with long-term follow-ups. Patient selection criteria for biofeedback for these conditions have not been established and reported sustained benefit past the treatment period are lacking (Hayes Inc., 2016; McKee and Moravec, 2010; Yilmaz, et al., 2010; Glasscoe and Quittner, 2008; McGinnis, et al., 2005).

**Cancer:** Patients undergoing oncologic therapy experience persistent pain, fatigue, anxiety and side effects from chemotherapy. In addition to pharmacotherapy, biofeedback has been proposed as an adjunct treatment modality for this patient population. However, there is insufficient evidence in the published peer-reviewed literature to support biofeedback for the management of cancer. There have been a limited number of studies with small patient populations (n=12-81), short-term follow-ups (e.g., 3 months) and in some studies, lack of a control group. Most studies were conducted prior to 2000. Biofeedback has not been shown to be effective in reducing cancer pain or chemotherapy side effects.

The American Cancer Society (2015) stated biofeedback under the supervision of a licensed biofeedback technician is a non-medical treatment that is sometimes used to help people relax and cope with pain and is typically used with other pain-relief methods. In their supportive care guideline on adult cancer pain, the National Comprehensive Cancer Network (NCCN) lists consideration of biofeedback as an option for psychological support (NCCN, 2021).

**Chronic Neck, Upper Back, and Low Back Pain:** Biofeedback has been proposed as a treatment modality for chronic back pain to help relieve the tension in the back muscles and alleviate pain. Henschke et al. (2010) conducted a systematic review of 30 randomized controlled trials (RCTs) that investigated behavioral treatment (e.g., biofeedback) for low back pain. There was low quality evidence (three RCTs; n=64) that EMG biofeedback was more effective than waiting list or progressive relaxation (one RCT; n=24).

Ostelo et al. (2005) conducted a systematic review of the literature to determine if behavioral treatments (including biofeedback) for nonspecific chronic low back pain (CLBP) were more effective than other treatments compared to waiting-list controls (WLC). Twenty-one randomized controlled trials met inclusion criteria. CLBP was defined as back pain that persisted for 12 weeks or more. Studies of individuals with CLBP caused by pathological entities including infection, neoplasm, fracture, osteoporosis and rheumatoid arthritis (RA) were excluded. The investigators reported that there is moderate evidence (three studies, n=88) that there is no significant difference between EMG biofeedback and WLC on behavioral outcomes in the short term. There is conflicting evidence (two studies, n=60) on the effectiveness of EMG biofeedback versus WLC on general functional status. There is limited evidence (one study, n=28) of EMG biofeedback for a small short-term positive effect on back-specific functional status. Cognitive behavioral treatment (CBT) was compared to EMG biofeedback in one study (n=28), which found no differences in the groups for pain or any behavioral outcome measures either in the short or long term. A combination of CBT and EMG biofeedback compared to WLC (four studies, n=134) found strong evidence for a short-term, positive effect on pain intensity, but no differences on behavioral outcomes or general functional status in the short term compared to WLC. More research is needed to determine what types of behavioral interventions are most effective for pain relief and which patients would benefit most from a specific type of behavioral treatment. The investigators stated no determination could be made from this review as to whether patients should be referred to behavioral treatment programs or to active conservative treatment programs.

The American College of Physicians (ACP) (2017) developed guidelines based on an evidentiary review of the literature to provide clinical recommendations on noninvasive treatment of low back pain. ACP recommended that select nonpharmacologic treatment be used initially. Low quality evidence reported that electromyography biofeedback reduced pain compared to wait list but there was no effect on function.

The American Society of Anesthesiologist Task Force on Chronic Pain Management and the American Society of Regional Anesthesia and Pain Medicine (2010) stated that psychological treatment including biofeedback “may be used as part of a multimodal strategy for low back pain and for other chronic pain conditions”.

Eslamian et al. (2020) sought to determine the differences between clinical effects of electroacupuncture and biofeedback therapy in addition to conventional treatment in patients with cervical myofascial pain syndrome (MPS). Fifty patients (N=50) aged 25-55 years of both sexes with chronic neck pain diagnosed with MPS (characterized by trigger points within taut bands) were randomly assigned to 2 equal groups of 25 individuals. The patients in electroacupuncture group were treated with standard acupuncture and concomitant electrical stimulation; those in biofeedback group received visual electromyography biofeedback therapy for muscle activity and relaxation. Both groups received the intervention 2 times a week for a total of 6 sessions. Basic exercise training and medicines were administered for all the patients. Authors concluded that both electroacupuncture and biofeedback therapies were found to be effective in management of MPS when integrated with conventional treatment. However, intergroup differences showed priority of acupuncture in some parameters vs biofeedback. Thus, electroacupuncture seems to be a better complementary modality for treatment of MPS in the neck and upper back area. Campo et al. (2021) evaluated the safety and efficacy of electromyographic and pressure biofeedback on pain, disability and work ability in adults with neck pain. Authors noted that moderate-quality evidence suggests biofeedback has a moderate effect on reducing short-term disability and a small effect on reducing intermediate-term disability. Biofeedback had no effect on pain or work ability in the short- and intermediate-term (low-to moderate-quality evidence). Authors conclude that biofeedback appears to have a small-to-moderate effect on reducing neck pain disability in the short- and intermediate-term, but no effect on pain or work ability. More trials reporting adverse events and comparing biofeedback to placebo are needed.

Wagner et al. (2021) evaluated evidence from the literature with a focus on the effect of biofeedback on pain reduction, overall symptom relief, physiological parameters and quality of life. Out of 651 studies, 37 quantitative studies of primary research evaluating pelvic pain conditions in male and female adults and children were included. They covered biofeedback interventions on anorectal disorders, chronic prostatitis, female chronic pelvic pain conditions, urologic phenotypes in children and adults and a single study on low back pain. For anorectal disorders, several landmark studies demonstrate the efficacy of biofeedback. For other subtypes of chronic pelvic pain conditions there is tentative evidence that biofeedback-assisted training has a positive effect on pain reduction, overall symptoms relief and quality of life. Authors conclude that for certain indications, biofeedback has been confirmed to be an effective treatment.

**Epilepsy:** In an effort to reduce abnormal brain waves and seizure frequency, biofeedback has been proposed for the treatment of epilepsy. Ramaratnam et al. (2008) conducted a meta-analysis of psychological treatments, including biofeedback, for epilepsy. Randomized and quasi-randomized studies were analyzed. Outcomes included quality of life and seizure frequency. Of the two trials including relaxation and behavioral therapy, one reported positive results by decreasing anxiety and enhancing adjustment. Another study of galvanic skin response reported reduction in seizure activity. A study using EEG biofeedback improved cognitive and motor functions in subjects with the greatest seizure reduction. The studies were deficient in methodology and, due to the limited number of studies, the evidence wasn't considered reliable. In their clinical guideline for diagnosing and managing epilepsy in children and adults, NICE (2016) stated that psychological interventions, including biofeedback, may be used as an adjuvant therapy to anti-epileptic drugs (AED) to improve quality of life in adults who are not receiving optimal benefit from AED. However, psychological interventions have not proven to affect seizure frequency and are not an alternative to pharmacological treatment.

**Fibromyalgia:** Biofeedback has been proposed for the treatment of fibromyalgia in an effort to facilitate and train an individual in maintaining a state of relaxation and decreased pain. In a randomized controlled trial, Babu et al. (2007) compared EMG biofeedback (n=15) to sham (n=15) and reported a significant decrease in pain and the number of tender points in the treatment group. However, there were no significant differences in the fibromyalgia impact questionnaire, or the six-minute walk test. Both groups experienced a significant decrease in FIQ and visual analogue scale but the decreases were greater in the biofeedback group. Reneau (2020) reports that fibromyalgia (FM) is associated with debilitating pain and a reduced heart rate variability (HRV), reflecting decreased emotional adaptability and resistance to stress. Given this, they postulate that heart rate variability biofeedback (HRVB) may be effective in improving HRV, thus increasing stress resistance and emotional adaptability and reducing pain. They reviewed 22 articles and included six in this review. Five reported HRVB as a treatment for chronic pain, and one for FM pain.

Overall, the articles in this review support the claim that HRVB is related to decreased pain. The researchers evaluated five HRVB programs, three on handheld devices and two on desktop computers. Authors conclude that despite the reviewed studies having methodological flaws, HRVB is a promising treatment for chronic pain. Larger, randomized controlled studies are needed to thoroughly evaluate the relationship between HRVB and FM pain.

**Functional Dyspepsia (FD):** Because low vagal tone may be a mediating mechanism by which psychological factors induce dyspepsia in FD, it has been hypothesized that biofeedback may be a helpful treatment modality by enhancing vagal tone, leading to improvement in parasympathetic activity and drinking capacity. In a randomized controlled trial (n=40) patients were allocated to investigation, information, and biofeedback with breathing exercises or to investigation and information only. Drinking capacity and quality of life significantly improved ( $p=0.02$ ,  $p=0.01$ , respectively) following biofeedback, but an improvement in baseline vagal tone was not noted (Hjelland, et al., 2007).

**Hypertension:** Because of its potential to decrease stress and enhance relaxation, biofeedback has been proposed for the treatment of hypertension. Greenhalgh et al. (2009) conducted a systematic review to determine the clinical benefits and long-term effects of biofeedback for the treatment of essential hypertension in adults. Forty-one studies, including 36 randomized controlled trials (n=1660), met inclusion criteria. Twenty-one trials used biofeedback only and 15 trials used biofeedback with other treatment modalities. No meta-analysis was completed due to the poor reporting quality of the studies and the large degree of heterogeneity of treatments and comparators. Overall, the trials included small patient populations, no follow-up or follow-up less than 12 months. Other limitations of the studies included the variation in interventions, inconsistencies in measurement of outcomes, and the conflicting and variable results. No consistent short- or long-term benefits in the control of hypertension were seen when biofeedback was compared to pharmacotherapy, sham biofeedback, no intervention or other behavioral therapies (e.g., relaxation, hypnosis, meditation, stress education).

Nakao et al. (2003) conducted a meta-analysis of 22 randomized controlled studies of essential hypertensive patients (n=905). Biofeedback intervention resulted in blood pressure reductions that were greater by 7.3 millimeters (mm) of mercury (Hg) systolic and 5.8 mmHg diastolic compared to nonintervention controls (such as clinical visits or self-monitoring of blood pressure). Compared to sham or nonspecific behavioral intervention controls, the net reductions in systolic and diastolic blood pressures by biofeedback intervention were 3.9 mmHg and 3.5 mmHg, respectively. Reviewers were unable to determine whether biofeedback itself had an antihypertensive effect beyond the general relaxation response because biofeedback was only found to be superior to sham or nonspecific behavioral intervention when combined with other relaxation techniques. The investigators concluded that large, randomized controlled trials are needed to determine whether biofeedback itself has an antihypertensive effect beyond the general relaxation response.

An evidence-based statement by the American Heart Association (AHA) included the investigation of biofeedback as an alternative therapy for lowering blood pressure (BP). AHA noted that the mechanisms responsible for BP lowering by biofeedback are incompletely described. Some evidence favors alteration in the autonomic nervous system balance. Systematic reviews and meta-analysis that have investigated biofeedback for this indication have reported conflicting results. Studies have been limited by “short duration, small sample sizes, difficulties with blinding, and significant heterogeneity when trial data were combined”. Also, some meta-analyses have combined multiple complementary medicine techniques in their analyses, making it difficult to assess the impact of biofeedback alone. Due to the paucity of data, recommendation for using a specific biofeedback method could not be made. Overall, no significant adverse effects were reported. Based on this review, AHA stated that biofeedback may be considered in clinical practice to lower BP. This is a Class IIB, Level of Evidence B, recommendation meaning that the usefulness/efficacy of biofeedback is less well established and there is greater conflicting evidence from randomized controlled trials or meta-analysis (Brooke, et al., 2013).

Elavally et al. (2020) investigated the effect of nurse-led home-based biofeedback intervention on the blood pressure levels among patients with hypertension. Uncomplicated primary hypertension outpatients were randomly assigned as study group (n = 173) and control group (n = 173) at a tertiary care hospital. Sociodemographic, clinical, and outcome variables [the baseline blood pressure and galvanic skin response (GSR)] were collected. Study group patients were given four teaching sessions of abdominal breathing-assisted relaxation facilitated by galvanic skin response (GSR) biofeedback. Daily home practice was encouraged and monitored to measure the effects on blood pressure and GSR at the end of the 1st, 2nd, and 3rd month of intervention. The study group participants showed significant decrease in mean (SD) systolic and diastolic blood

pressure. In contrast, control group participants had a mild increase in the mean systolic and diastolic blood pressure values from pretest to posttests. GSR showed a significant increase from 559.63 (226.33) to 615.03 (232.24), ( $F = 80.21$ ) from pretest to posttest III. Authors concluded that use of home-based biofeedback-centered behavioral interventions enabled BP reduction among hypertensive patients. Further studies should use biochemical markers of sympathetic nervous system activity to endorse this home-based chronic illness intervention.

Burlaco et al. (2021) aimed to systematically review the literature to investigate the impact of HRV modulation through HRV-biofeedback on clinical outcomes in patients with CVD. Patients in the HRV-biofeedback group had significantly lower rates of all-cause readmissions than patients who received psychological education. Heart failure following HRV-biofeedback displayed an inverse association with stress and depression. HRV-biofeedback had beneficial effects on different cardiovascular diseases documented in clinical trials, such as arterial hypertension, heart failure, and coronary artery disease. Fournié et al. (2021) performed a review according to eligibility criteria including adult chronic patients, HRVB as main treatment with or without control conditions, and psychophysiological outcomes as dependent variables. In total, 29 articles were included. Reported results showed the feasibility of HRVB in chronic patients without adverse effects. Significant positive effects were found in various patient profiles on hypertension and cardiovascular prognosis, inflammatory state, asthma disorders, depression and anxiety, sleep disturbances, cognitive performance and pain, which could be associated with improved quality of life. Improvements in clinical outcomes co-occurred with improvements in heart rate variability, suggesting possible regulatory effect of HRVB on autonomic function. Authors concluded that HRVB could be effective in managing patients with chronic diseases.

**Irritable Bowel Syndrome (IBS):** The clinical guideline on the management of irritable bowel syndrome (IBS) published by NICE (2008; updated 2017) stated that reviews of biofeedback suggested a positive effect on the control of IBS symptoms, but evidence was limited and not sufficient to make recommendations. A systematic review of the literature identified four randomized controlled trials that met inclusion criteria. One study compared biofeedback to counseling and three studies evaluated multi-component therapy (a combination of educational information, progressive relaxation therapy, thermal biofeedback treatment and training in stress coping strategies) compared to symptom monitoring or attention placebo controls. There was limited, weak evidence to show a statistically significant improvement in global symptoms for biofeedback and reduction in diarrhea compared to symptom monitoring. No significant differences between biofeedback and attention placebo or between symptom monitoring and attention placebo were reported, but there was much uncertainty due to wide confidence intervals. There was insufficient evidence to determine the effects of biofeedback on pain, bloating and constipation. A 2019 Cochrane Review by Goldenberg et al. (2019) also concluded that there is currently not enough evidence to assess whether biofeedback interventions are effective for controlling symptoms of IBS. A 2019 Cochrane Review by Goldenberg et al. (2019) also concluded that there is currently not enough evidence to assess whether biofeedback interventions are effective for controlling symptoms of IBS.

**Labor Pain:** In a systematic review, Jones, et al. (2012) summarized the evidence on the efficacy and safety of non-pharmacological and pharmacological interventions to manage labor pain. Fifteen Cochrane reviews ( $n=255$  trials) and three non-Cochrane reviews ( $n=55$  trials) met inclusion criteria. There was insufficient evidence from four randomized controlled trials ( $n=201$ ) to determine if biofeedback was more effective than placebo or other interventions for labor pain management.

Barragán et al. (2011) conducted a systematic review of randomized controlled trials to evaluate the efficacy of biofeedback in the management of labor pain. Four trials ( $n=186$ ) met inclusion criteria and primarily used EMG biofeedback. There were no significant differences between biofeedback and the control groups in terms of assisted vaginal birth, caesarean section, augmentation of labor and the use of pharmacological pain relief. Some studies reported that EMG biofeedback may have had some positive effects early in labor, but as labor progressed there was a need for additional pharmacological analgesia.

**Knee Conditions:** Richard et al. (2017) conducted a systematic review of the literature to evaluate the effectiveness of real-time biofeedback as a method for gait retraining to reduce knee adduction movement (KAM) in patients with knee osteoarthritis (KOA). Twelve uncontrolled studies met inclusion criteria. Seven studies used healthy subjects and five studies enrolled patients with KOA. Because of the lack of studies reporting between-group effects, this review focused on within-group effects. Within-group standardized mean differences (SMDs) for reduction of KAM in healthy controls ranged from 0.44 to 2.47 and from 0.29 to 0.37 in patients with KOA. In patients with KOA, improvements were reported in pain and function, with SMDs ranging from 0.55 to 1.16.



Limitations of the studies included: small number of studies that enrolled KOA patients; small patient populations; heterogeneity of study design, methods of feedback and number of training sessions (many studies only reported on one session); short-term follow-ups (e.g., one month); and lack of a comparator and control group. The authors noted that there was insufficient information to conclude the optimal method of feedback delivery or the optimal instructions for subjects to achieve KAM reductions. Additional studies with large patient populations and long-term follow-up are needed to support biofeedback for this indication.

Wasielowski et al. (2011) conducted a systematic review of eight randomized controlled trials (n=319 subjects) to evaluate the effectiveness of electromyographic biofeedback (EMGB) of the quadriceps femoris muscle for the treatment of knee conditions. Diagnosis included patellofemoral pain syndrome (two trials; n=86), anterior cruciate ligament reconstruction (two trials; n=52), arthroscopic surgery (two trials; n=91) or osteoarthritis (two trials; n=90). EMGB appeared to benefit short-term postsurgical pain or quadriceps strength in three out of the four postsurgical investigations but was reported ineffective for chronic knee conditions including patellofemoral pain and osteoarthritis. Limitations of the studies included small heterogeneous patient populations, variability in interventions and outcomes, and poor methodology. The authors stated that the results should be viewed with caution due to the limited data and poor studies.

Karaborklu Argut et al. (2022) presented an evidence-based overview of the current utilization and the effectiveness of therapeutic Electromyographic Biofeedback (EMG-BF) in rehabilitation after orthopedic knee surgeries. Eight RCTs investigating effectiveness of the EMG-BF in rehabilitation after orthopedic knee surgeries were identified. Most of the included studies reported that EMG-BF was more effective compared to home exercises, standard rehabilitation program or electrical stimulation for improving quadriceps strength or activation. Besides, EMG-BF was revealed positive results in functional assessments except gait velocity and IKDC. Only two studies reported knee ROMs were significantly improved in favor of EMG-BF. Authors concluded that EMG-BF seems to control pain and improve quadriceps femoris strength and functionality. However, the results are inconclusive regarding knee ROM. Although available high-quality evidence is limited, EMG-BF might be a part of the rehabilitation after knee surgeries.

Xie et al. (2021) aimed to determine whether EMG-biofeedback is effective for improving the range of motion (ROM), physical function, and pain relief in patients after knee surgery. Randomized controlled trials (RCTs) assessing the effect of EMG-biofeedback after any knee surgery were retrieved. This review identified 773 unique studies, and six RCTs were in the final meta-analysis. EMG-Biofeedback treatment has a significant difference compared to other rehabilitation therapy in knee ROM improving). Moreover, there was no significant difference in pain and physical function. The results illustrate that EMG-biofeedback can improve knee ROM in patients after knee surgery. However, it is not superior to other rehabilitation methods for pain relief and physical function improvement.

Glatke et al. (2022) completed a systematic review on rehabilitation after ACL reconstructive surgery. A total of 824 articles from 2012 to 2020 were identified using multiple search engines. Fifty Level-I or II studies met inclusion criteria. Authors stated that electromyography biofeedback may help to regain muscular function.

Ananías et al. (2024) synthesized the available evidence on the effect of electromyographic biofeedback in the treatment of quadriceps strength following ACL surgery. Eight articles were included in the qualitative analysis, and four articles were included in the quantitative analysis. The interventions lasted between 4 and 12 weeks. Three studies evaluated the effect of biofeedback on quadriceps strength; of these, two studies showed a significant difference in favour of the biofeedback group. In addition, biofeedback was found to improve knee extension and balance (one study). There was no significant difference in Lysholm score or pain between the biofeedback group and the control group. Authors concluded that electromyographic biofeedback in knee rehabilitation could be useful following ACL reconstruction surgery.

Souto et al. (2024) compared the effectiveness of adjunct treatments combined with exercise to exercise alone in people with patellofemoral pain (PFP) and explore the quality of intervention descriptions in randomized controlled trials (RCTs). RCTs that evaluated the effectiveness of any adjunct treatment combined with exercise to exercise alone on self-reported pain and function in people with PFP were included. They included 45 RCTs (2023 participants), with 25 RCTs (1050 participants) contributing to meta-analyses. Pooled analysis indicated very low-certainty evidence that neuromuscular electrical stimulation or monopolar dielectric diathermy combined with exercise leads to small and large improvements in self-reported pain when compared with exercise alone in the short-term. For self-reported pain and function, very low-certainty evidence indicates that knee taping, whole-body

vibration, electromyographic biofeedback and knee brace combined with exercise do not differ from exercise alone. Relative to biofeedback, authors concluded that electromyographic biofeedback do not offer additional benefits to exercise alone.

**Nonneuropathic Voiding Disorders:** Fazeli et al. (2014) conducted a systematic review and meta-analysis to evaluate biofeedback for the treatment of nonneuropathic daytime voiding disorders (NVD) in children. The hallmark of nonneuropathic voiding disorders is lower urinary tract symptoms with or without urinary incontinence. Five randomized controlled trials (n=487) met inclusion criteria and four studies (n=382) were included in the meta-analysis. At six months follow-up, there were no significant differences in the number of cases with resolved incontinence, mean maximum urinary flow rate or the likelihood of urinary tract infection with biofeedback vs. control group without biofeedback. The data does not support biofeedback for the treatment of this subpopulation.

Qi et al. (2022) assessed the efficacy of biofeedback treatment for children's non-neurogenic voiding dysfunction (NVD), which is a syndrome characterized by lower urinary tract symptoms (LUTs) because of the inability to relax the external sphincter. Patients with NVD always suffer from urinary tract infections (UTI), incontinence, constipation. Fifteen studies and 1274 patients were included in the systemic review, seven RCTs and 539 patients were included in meta-analysis. Meta-analysis showed efficacy of biofeedback treatment in following aspects, (1) relieving UTI, (2) reducing PVR, (3) increasing maximum urine flow rate and average urine flow rate, (4) relieving constipation, (5) improving abnormal voiding pattern and abnormal EMG during voiding. The improvement of UTI symptoms, maximum urine flow rate and average urine flow rate took a longer time (12 months). In terms of daytime incontinence, nighttime incontinence, no significant difference was found between biofeedback treatment and standard urotherapy. The qualitative analysis showed that biofeedback treatment was beneficial for NVD. Authors concluded that compared with standard urotherapy, biofeedback treatment is effective for some symptoms, such as UTI and constipation, and can improve some uroflowmetric parameters, such as PVR. Biofeedback treatment seems to have a better long-term effect.

Li et al. (2024) investigated the effect of biofeedback (BF) on the rehabilitation of children with non-neurological dysfunctional voiding (NDV). Meta-analysis revealed that BF increased the maximum urinary flow rate, improved urination time, and reduced the postvoid residual and urinary tract infection incidence. Electromyogram activity and abnormal urination patterns improved, with effects persisting for more than 1 year. However, the effect of BF on the mean urinary flow rate in children with NDV was significant only after 1 year of follow-up. Authors concluded that existing evidence indicates that BF can enhance urinary parameters and patterns in children with NDV. However, its effectiveness in addressing constipation, daytime urinary incontinence, and nocturnal urinary incontinence is not substantial. High-quality randomized controlled trials can offer additional insights.

**Raynaud's Syndrome:** Proponents of biofeedback for Raynaud's state that using thermal biofeedback to produce vasodilation may help relieve the severity and frequency of attacks. Malenfant et al. (2009) conducted a systematic review and meta-analysis of randomized controlled trials on complementary and alternative medicine, including biofeedback (n=5 studies), for the treatment of Raynaud's phenomenon. The outcomes of the biofeedback studies (n=15–155) favored sham therapy over biofeedback ( $p<0.02$ ). There were no significant differences in frequency or duration or severity of Raynaud's attacks. The authors concluded that biofeedback is not an effective therapeutic intervention for the treatment of Raynaud's.

**Recurrent Urinary Tract Infection:** Minardi et al. (2010) conducted a randomized controlled trial to evaluate the efficacy of uroflowmetry biofeedback and pelvic floor relaxation biofeedback in women (n=86) with more than a three-year history of recurrent urinary tract infections (UTI) (i.e., three or more symptomatic episodes per year) and dysfunctional voiding. The authors defined dysfunctional voiding as an abnormally learned spectrum of voiding behavior in neurologically normal individuals. The women were randomized to one of four groups: group 1 (n=24), uroflowmetry biofeedback; group 2 (n=21), biofeedback training of the pelvic floor muscles; group 3 uroflowmetry biofeedback combined with biofeedback training of the pelvic floor muscles; and group 4 no treatment. Patients also received antibiotics during the study when indicated. At the three-, six- and 12-month follow-ups there were significant improvements ( $p<0.05$ , each), which remained stable, in all of the following outcome measures: storage and emptying symptoms, mean flow rate, flow time, voiding and volume; overall voiding pattern; post-void residual urine; mean opening detrusor pressure and detrusor pressure at maximum flow; and the prevalence of UTI. No significant improvements were seen in the untreated group. At 24 months in the treated groups, the storage and emptying symptoms and voiding patterns were similar to baseline values in 55% of patients, and the incidence of UTIs was similar in 45% of patients. The authors noted that this was the

first study of pelvic floor therapy for the treatment of recurrent UTIs in women. Limitations of the study include the small patient population, short-term follow-up and the number of patients lost to follow-up (142 were originally enrolled).

**Rheumatoid Arthritis (RA):** Biofeedback has been proposed for the treatment of RA to help alleviate tension, stress, anxiety, insomnia and other symptoms that may cause acute flares and/or enhance arthritic pain. Astin et al. (2002) conducted a systematic review of the literature to investigate the effect of psychological interventions (including biofeedback) on patients with RA. Outcome measures included functional ability, pain, tender joints, psychological status and coping ability. Twenty-five randomized controlled trials (n=1676) met inclusion criteria. Because separate results by type of intervention (i.e., relaxation, biofeedback, CBT) were not identified, the authors could not report which psychological interventions or combinations of interventions were most effective and for which types of patients. Methodological flaws in the studies included: inadequate description of controls and the effect sizes were not always consistent with signs of confidence intervals. The authors concluded that more research was needed to determine which treatments may be of benefit for patients with RA.

**Sleep Bruxism:** Biofeedback has been proposed as a treatment option for sleep bruxism, a sleep-related disorder characterized by teeth grinding or jaw clenching. In a systematic review of seven randomized controlled trials (n=240), Wang et al. (2014) concluded that the evidence did not support biofeedback for this condition. Meta-analysis showed no significant differences between biofeedback and controls (p=0.26). The studies were limited by the heterogeneity of the biofeedback modalities (i.e., auditory, electrical and visual feedback) and regimens, and the use of various control modalities (e.g., splint, occlusal adjustment) and outcome measures. The classification of risk of bias was moderate to high. Jokubauskas and Baltrušaitytė (2018) updated the review published by Wang et al in 2014. The review focuses on the most recent literature on management of sleep bruxism (SB) with biofeedback. Six articles of 2320 identified citations involving 86 adult participants were included in the qualitative synthesis. Of them, 4 were randomized controlled trials (RCTs) and 2 were uncontrolled before-after studies. Different feedback modalities (electrical, auditory and vibratory stimulus) were investigated. The meta-analysis indicated a non-significant difference in electromyographic-measured SB episodes per hour after one night of contingent electrical stimulation (CES) compared with placebo control, yet a significant difference was shown after five nights of CES. The quality of evidence was graded from low to moderate, due to imprecision and inconsistency between studies. Authors concluded that one of the biofeedback modalities, CES, is effective in reducing SB-related motor activities after a short-term treatment period. However, evidence of long-term effects is lacking. Further longitudinal studies with larger samples are necessary to acknowledge the clinical application of biofeedback. Bussadori et al. (2020) mapped the evidence from systematic reviews (SR), examining the effects of interventions to improve chronic pain related to bruxism. There was no difference in pain and bruxism frequency between biofeedback therapy and an inactive control group. Authors concluded that there was no evidence was provided to support the recommendation of biofeedback therapy and drug therapy. There is still a need for more methodologically rigorous randomized clinical trials (RCT) to be conducted on the efficacy and safety of different therapies for SB.

Ainoosah et al. (2024) compared the effectiveness of different occlusal splints in managing sleep bruxism. Out of the total of 808 articles that were evaluated, only 15 articles were found to meet the specified inclusion criteria. Adjustable splints, such as full-occlusion biofeedback splints, were more effective in reducing sleep bruxism episodes, improving patient-reported symptoms, and enhancing overall well-being.

Soares-Silva et al. (2024) evaluated, qualified, and summarized evidence presented in systematic reviews (SR) on treatments for bruxism. A total of 31 SR were included. Sixteen showed a positive effect on episodes of bruxism (BE), while two had negative, one had neutral, and nine had inconclusive effects. Pharmacological treatment, oral rehabilitation, and other therapeutic approaches presented inconclusive or negative effects on BE, while oral appliances showed controversial effects. Biofeedback, physical therapy, laser therapy, and botulinum toxin showed positive effects on the reduction of BE. Authors concluded that biofeedback, physical therapy, laser therapy, and botulinum toxin showed positive effects on the reduction of BE; there is still a lack of studies to support the safe and long-term use of these therapies.

**Temporomandibular Disorders (TMD)/Temporomandibular Joint (TMJ) Disorders:** As in other chronic pain conditions, biofeedback has been investigated to determine if relaxation and relief of stress and tension following biofeedback would alleviate the pain of TMD. A systematic review by Medicott and Harris (2006) included seven randomized controlled trials which evaluated the effectiveness of relaxation training or biofeedback in the management of TMD. From the review of these studies, the authors stated that programs involving relaxation

techniques and biofeedback, EMG training, and proprioceptive reeducation may be more effective than placebo or occlusal splints in decreasing pain and increasing total vertical opening in patients with acute or chronic myofascial or muscular TMD. However, it was noted by the authors that “these recommendations should be viewed cautiously.”

In 2005 systematic review, Crider et al. reported on six randomized controlled trials regarding the efficacy of biofeedback-based therapy for TMD. Two trials included surface electromyographic (SEMG) training of masticatory muscles; two combined SEMG with cognitive-behavioral therapy (CBT); and two involved biofeedback-assisted relaxation training (BART). The review determined the extent that each intervention met treatment efficacy criteria established by the Association for Applied Psychophysiology and Biofeedback (AAPB). Based upon the review of the studies, the authors stated that SEMG training and BART were “probably an efficacious treatment” and SEMG with CBT is an efficacious treatment. They recommended additional studies to identify specific treatment combinations.

Yao et al. (2024) explored the comparative effectiveness of available therapies for chronic pain associated with temporomandibular disorders (TMD). 233 trials proved eligible for review, of which 153-enrolling 8713 participants and exploring 59 interventions or combinations of interventions-were included in network meta-analyses. All subsequent effects refer to comparisons with placebo or sham procedures. Effects on pain for eight interventions were supported by high to moderate certainty evidence. The three therapies probably most effective for pain relief were cognitive behavioral therapy (CBT) augmented with biofeedback or relaxation therapy, therapist-assisted jaw mobilization, and manual trigger point therapy. Five interventions were less effective, yet more effective than placebo: CBT, supervised postural exercise, supervised jaw exercise and stretching, supervised jaw exercise and stretching with manual trigger point therapy, and usual care (such as home exercises, self-stretching, reassurance). Moderate certainty evidence showed four interventions probably improved physical functioning: supervised jaw exercise and stretching, manipulation, acupuncture, and supervised jaw exercise and mobilization. The evidence for pain relief or physical functioning among other interventions, and all evidence for adverse events, was low or very low certainty.

Busse et al. (2024) determined the comparative effectiveness of available therapies for chronic pain associated with temporomandibular disorders (TMD). This clinical practice guideline notes the following recommendations:

- For patients living with chronic pain ( $\geq 3$  months) associated with TMD, and compared with placebo or sham procedures, the guideline panel issued:
  - (1) strong recommendations in favour of cognitive behavioural therapy (CBT) with or without biofeedback or relaxation therapy, therapist-assisted mobilisation, manual trigger point therapy, supervised postural exercise, supervised jaw exercise and stretching with or without manual trigger point therapy, and usual care (such as home exercises, stretching, reassurance, and education);
  - (2) conditional recommendations in favour of manipulation, supervised jaw exercise with mobilisation, CBT with non-steroidal anti-inflammatory drugs (NSAIDs), manipulation with postural exercise, and acupuncture;
  - (3) conditional recommendations against reversible occlusal splints (alone or in combination with other interventions), arthrocentesis (alone or in combination with other interventions), cartilage supplement with or without hyaluronic acid injection, low level laser therapy (alone or in combination with other interventions), transcutaneous electrical nerve stimulation, gabapentin, botulinum toxin injection, hyaluronic acid injection, relaxation therapy, trigger point injection, acetaminophen (with or without muscle relaxants or NSAIDs), topical capsaicin, biofeedback, corticosteroid injection (with or without NSAIDs), benzodiazepines, and  $\beta$  blockers; and (4) strong recommendations against irreversible oral splints, discectomy, and NSAIDs with opioids.

Authors note that these recommendations apply to patients living with chronic pain ( $\geq 3$  months duration) associated with TMD as a group of conditions, and do not apply to the management of acute TMD pain. When considering management options, clinicians and patients should first consider strongly recommended interventions, then those conditionally recommended in favour, then conditionally against. In doing so, shared

decision making is essential to ensure patients make choices that reflect their values and preference, availability of interventions, and what they may have already tried.

**Tinnitus:** Weise et al. (2008) conducted a randomized controlled trial to compare the effects of biofeedback (n=63) to a wait-list control group (WLG) (n=67) in patients with chronic tinnitus (i.e., more than six months duration). Patients underwent 12, one-hour EMG biofeedback sessions with tinnitus-specific cognitive-behavioral therapy (CBT) (e.g., directing attention away from tinnitus, relapse prevention) over a three-month period. Final follow-up occurred six months following cessation of treatment. Following treatment, intention-to-treat statistical analysis based on results of interviews and self-reported questionnaires showed significantly less emotional and cognitive distress; less intrusive tinnitus, less auditory perceptual difficulties, less sleep disturbances and fewer somatic complaints in the biofeedback group ( $p < 0.01$  for each). No significant differences were reported in the WLG. Compared to pretreatment and the WLG, patients in the biofeedback group reported fewer feelings of helplessness, increased feelings of resourcefulness, fewer catastrophizing self-statements, and more helpful coping self-statements. However, no significant effect was found for depressive and general psychopathological symptoms. Following a waiting period, 52 WTG patients received biofeedback and showed a significant improvement in outcomes. The authors noted that the study was limited by the WTG instead of an active treatment control group (CBT without biofeedback). Other limitations of the study are the short-term follow-up, and the dropout rate (n=26).

**Upper Limb Pain:** A limited number of studies have been conducted to determine if the muscle relaxation effect of biofeedback could help alleviate the pain of repetitive strain in the upper limbs. Karjalainen et al. (2004) conducted a systematic review of the literature to determine the effectiveness of biopsychosocial rehabilitation for upper-limb repetitive strain injuries among working-age adults. Two prospective randomized studies (n=80) met inclusion criteria and both were considered to be of low quality due to methodological flaws. Studies which included EMG biofeedback as the only component of physiological rehabilitation were excluded. The authors concluded that there were no differences in effect between applied relaxation, EMG biofeedback plus applied relaxation, and waiting-list controls after eight weeks and six months of follow-up.

Feng et al. (2023) aimed to guide clinical treatment by identifying the most effective physical therapy interventions for improving clinical symptoms in patients with post-stroke shoulder-hand syndrome (SHS) using Bayesian network meta-analysis. A total of 45 RCTs with 3,379 subjects were included, and the intervention efficacy of 7 physical factor therapies (PFT) combined with rehabilitation training (RT) was explored. Compared with the control group, all the PFT + RT included were of statistical benefit in improving limb motor function and pain relief. Also, our study indicated that EMG biofeedback combined with RT (BFT + RT) might be the best choice for patients with post-stroke SHS. Authors concluded that EMG biofeedback combined with rehabilitation training may be the best physical therapy for improving upper limb motor function and relieving pain in patients with post-stroke SHS according to our Bayesian network meta-analysis results. However, the above conclusions need further analysis and validation by more high-quality RCTs.

**Vulvodynia:** Following the hypothesis that vulvodynia, also called vulvar vestibulitis or vulvar vestibulodynia, may be due to an abnormality in pelvic floor muscle tone, biofeedback has been investigated as a treatment modality for muscle training. In a randomized controlled study, Bergeron et al. (2001) prospectively evaluated and compared EMG biofeedback (12-week trial), group cognitive-behavioral (12-week trial), and vestibulectomy in the treatment of dyspareunia resulting from vulvar vestibulodynia. Seventy-eight women were randomly assigned to one of the three treatment regimens. Following treatment, all groups reported statistically significant reductions on pain measures up to the six-month follow-up. The vestibulectomy group was significantly more successful than the other two groups, reporting a 70% mean reduction in pain and a greater quality of life improvement. The biofeedback participants experienced a higher six-month dropout rate, reflecting patient difficulty following through with the long-term and repetitive treatment protocols. The authors stated, that the results should be interpreted with caution because there were significantly more participants in the vestibulectomy condition who refused to undergo the treatment they had been randomized to, as compared to participants in the two other treatment conditions”.

The American Society for Colposcopy and Cervical Pathology's (ASCCP) vulvodynia guideline update (Stockdale, et al., 2013) stated that biofeedback may be used in the treatment of vulvodynia to aid patients in confronting and reducing pain.

In a 2016 updated Committee Opinion on persistent vulvar pain, the American Congress of Obstetricians and Gynecologists (ACOG) and American Society for Colposcopy and Cervical Pathology (ASCCP) recommendations and conclusions stated that women with vulvodynia should be assessed for pelvic floor dysfunction. Biofeedback and/or physical therapy, including pelvic floor physical therapy can be used to treat localized and generalized vulvar pain especially if there is concomitant vaginismus.

Nascimento et al. (2024) assessed the efficacy of physiotherapy for vulvodynia. A total of 2,274 articles were retrieved. Seven studies met the criteria and were included in a systematic review, which included a total of 477 patients. The interventions included were electromyography biofeedback (n = 2), transcutaneous electrical nerve stimulation (n = 1), transcranial direct current stimulation (n = 1), low-intensity shockwave (n = 1), physiotherapy treatment (n = 1), and pelvic floor exercise with behavioral modification (n = 1). All studies evaluated pain reduction, 5 evaluated sexual function, and 2 evaluated quality of life. All interventions were effective for the main outcomes; only the transcranial direct current stimulation intervention showed no significant difference when compared with the placebo or sham group. Three studies presented a high risk of bias due to the lack of blinding. Authors concluded that the studied interventions (electromyography biofeedback, transcutaneous electrical nerve stimulation, shockwave, physiotherapy, and pelvic floor exercise) seem to improve pain, sexual function, and quality of life. However, the heterogeneity of the studies prevented meta-analysis. In addition, well-designed trials are needed to improve the certainty of this evidence.

### **EEG Biofeedback/Neurofeedback**

The evidence in the clinical trials has not established clinical efficacy and effectiveness of EEG biofeedback for any indication. Studies include small patient populations and heterogeneous types of neurofeedback with short-term follow-ups (Lee, et al., 2015; Angelakis, et al., 2007; Dohrmann, et al., 2007; McDonough-Means and Cohen, 2007).

Renton et al. (2017) conducted a systematic review to evaluate the effectiveness of neurofeedback (NF) as a form of cognitive rehabilitation therapy for the treatment of stroke patients. Studies included subjects who were affected by a cognitive deficit following stroke (e.g., memory loss, loss of executive function, speech impairment). Seven studies met inclusion criteria including one randomized controlled trial, one non-randomized comparative trial, one case series and four case reports. Study designs and NF therapy and training protocols were heterogeneous. NF protocols were highly specific to each study (i.e. feedback location, number of sessions, training task involved, etc.). The majority of patients demonstrated moderate cognitive improvements in their respective pre-post NF outcome measures including reported improvements in memory, mood, concentration, energy, reading and speech abilities, and/or motivation. The authors noted that it was unlikely that NF alone was responsible for the improved results. Because of the heterogeneity of the studies, meta-analysis could not be performed. Limitations of the studies include: heterogeneous types of NF therapy; small patient populations; lack of a comparator; heterogeneity of the study designs; and poor quality of the studies. There is insufficient evidence to support NF therapy for cognitive rehabilitation of stroke patients.

Reiter et al. (2016) conducted a systematic review of the literature to assess the effectiveness of neurofeedback (NF) for the treatment of posttraumatic stress disorder (PTSD). Five studies including one randomized controlled trial met inclusion criteria. Three studies used neurofeedback for combat-related PTSD. One study focused on children with insecure attachment and trauma-related PTSD and one study included participants with PTSD related to childhood abuse. NF approach included alpha wave, alpha/theta training, sensorimotor rhythm, or combination NF. Training sessions varied from 30 minutes to one hour and ranged from one single session to 30 sessions. Three studies reported a statistically significant reduction in targeted symptomatology while some measures failed to show any improvement. Limitations of the studies include: limited number of studies; small patient populations (10–29); lack of female subjects; short-term follow-ups; lack of a comparator, and heterogeneity of treatment protocol and outcomes. Data are insufficient to support neurofeedback as an effective treatment option for PTSD. Additional research using well-designed randomized controlled trials with large patient populations is needed to establish which neurofeedback approach is clinically effective for PTSD.

Luctkar-Flude et al. (2015) conducted a systematic review of the literature to evaluate the safety and effectiveness of neurofeedback of the management of fatigue and cognitive impairment. Seven randomized, three quasi-randomized and four nonrandomized trials (case series and retrospective reviews) met inclusion criteria. A study was eligible for inclusion if it included adult cancer survivors, individuals with other chronic health conditions or nonclinical populations seeking to decrease fatigue and/or enhance cognitive abilities. Two studies included cancer patients. Most of these studies reported positive results for at least one fatigue or cognitive outcome in a

variety of clinical populations (traumatic brain injury, fibromyalgia, CNS problems) and nonclinical (college students, adults, elderly). Limitations of the studies included: small patient populations; heterogeneity of the types of neurofeedback, comparators, number of training sessions, outcome measures and diagnosis; subjects lost to follow-up; and short-term follow-ups. Only four studies reported side effects or safety issues. Due to the limitations of the studies firm conclusions could not be made regarding the effectiveness of neurofeedback for fatigue and cognitive impairment including cancer patients.

A Hayes (2003) review of six studies that met inclusion criteria concluded that “there is insufficient evidence from the available peer-reviewed literature to conclude that EEG biofeedback therapy is effective for the treatment of disorders such as epilepsy, insomnia, depression, mood disorders, posttraumatic stress disorder, alcoholism, drug addiction, or menopausal symptoms”. Limitations of the studies included small patient populations, inadequate or no controls, lack of randomization or comparison to conventional therapies, and/or long-term follow-up, as well as inconsistent outcome measures and incomplete reporting of data. Because of these methodological flaws, Hayes stated that “no definitive conclusions regarding the efficacy of EEG biofeedback can be drawn.” In a subsequent literature search (2008), Hayes’ conclusions had not changed. This report has been archived.

The American Academy of Pediatrics (AAP) Task Force on Mental Health (2010) published a mental health tool kit for primary care clinicians as a guide for mental health care for pediatric practices. Included in the supplement is an “Evidence Based Child and Adolescents Psychosocial Interventions” document developed by using data from the PracticeWise Evidence-Based Services Database. The table lists primary problem areas and interventions based on the level of support. Biofeedback is listed as a level 4, minimal support, for anxious or avoidant behaviors and a level 5, no support for autism spectrum disorders. According to the authors the ratings are based on an ongoing review of randomized clinical psychosocial and combined treatment trials for children and adolescents with mental health needs.

Patel et al. (2020) evaluated the effectiveness and safety of neurofeedback (NFB) in alleviating pain and pain-associated symptoms in chronic pain patients. Twenty-one studies were included. Reduction in pain following NFB was reported by one high-quality RCT, five of six low-quality RCT or NRCT and 13 of 14 case-series. Pain reduction reported by studies ranged from 6% to 82%, with 10 studies reporting a clinically significant reduction in pain of >30%. The overall effect size was medium (Cohen's  $d = 0.76$ ). Studies were highly heterogeneous. Improvements in depression, anxiety, fatigue and sleep were also seen in some studies. Common side-effects included headache, nausea and drowsiness. Authors concluded that neurofeedback is a safe and effective therapy with promising but largely low-quality evidence supporting its use in chronic pain. Further high-quality trials comparing different protocols is warranted to determine the most efficacious way to deliver NFB.

Steingrimsdóttir et al. (2020) aimed to assess whether EEG-NF, compared with sham NF, other treatment, or no treatment, is effective for PTSD. Primary outcomes were self-harm, PTSD symptoms, level of functioning and health-related quality of life. Four RCTs were included (123 participants). Suicidal thoughts were significantly reduced after EEG-NF compared with a waiting list in a small study. PTSD symptoms were assessed in all studies with different instruments. Results were consistently in favor of EEG-NF with large effect sizes. One study reported significantly improved level of executive functioning and one study a reduction in use of psychotropic medication. Complications were scarcely reported. Certainty of evidence was assessed as very low for the four assessed outcomes. Authors concluded that based on four RCTs, with several study limitations and imprecision, it is uncertain whether EEG-NF reduces suicidal thoughts, PTSD symptoms, medication use, or improves function. Although all studies showed promising results, further studies are needed to increase the certainty of evidence.

Hesam-Shariati et al. (2022) synthesized the evidence from randomized controlled trials (RCTs) to evaluate the effect of EEG neurofeedback on chronic pain using random effects meta-analyses. Additionally, they performed a narrative review to explore the results of non-randomized studies. Ten RCTs and 13 non-randomized studies were included. The primary meta-analysis on nine eligible RCTs indicated that although there is low confidence, EEG neurofeedback may have a clinically meaningful effect on pain intensity in short-term. Removing the studies with high risk of bias from the primary meta-analysis resulted in moderate confidence that there remained a clinically meaningful effect on pain intensity. Authors concluded that although there is promising evidence on the analgesic effect of EEG neurofeedback, further studies with larger sample sizes and higher quality of evidence are required.

Fernández-Alvarez et al. (2022) conducted a meta-analysis of studies extracted from PubMed, Scopus, Web of Science and Embase with two objectives: A first group comprising studies patients with major depressive disorder (MDD) and a second group including studies targeting depressive symptomatology reduction in other mental or medical conditions. In the first group of studies including patients with MDD, moderator analyses indicate that treatment efficacy is only significant when accounting for experimental design, in favor of randomized controlled trials (RCTs) in comparison to non RCTs, whereas the type of neurofeedback, trial design, year of publication, number of sessions, age, sex and quality of study did not influence treatment efficacy. In the second group of studies, a small but significant effect between groups was found in favor of bio- and neurofeedback against control groups. Moderator analyses revealed that treatment efficacy was not moderated by any of the sociodemographic and clinical variables. Authors concluded that heart rate variability (HRV) biofeedback and neurofeedback are associated with a reduction in self-reported depression. Despite the fact that the field has still a large room for improvement in terms of research quality, the results presented in this study suggests that both modalities may become relevant complementary strategies for the treatment of MDD and depressive symptomatology in the coming years.

Lima et al. (2022) reviewed the studies that investigated the effects of EEG neurofeedback in subjects with alcohol use disorder (AUD) and it proposes to discuss this intervention as a tool for reducing harm and risk in AUD. Most of the papers analysed used the alpha/theta protocol to reduce the 'hyperexcitation' of the nervous system. This protocol provides relaxation, decreases anxiety or stress, prevents alcohol relapse, maintains abstinence and increases the feeling of well-being. EEG neurofeedback has important effects on AUD and anxiety or stress. Studies reinforce the use of EEG neurofeedback as an alternative tool for reducing harm and risk in AUD. EEG neurofeedback is an intervention to treat AUD, specifically, to reduce harm and risk. However, more randomised studies are necessary to consolidate and confirm the effectiveness of the technique despite these findings.

Pindi et al. (2022) provide 1) a state-of-art qualitative review of real-time functional MRI (RT-fMRI-NF) studies aiming at alleviating clinical symptoms in a psychiatric population; 2) a quantitative evaluation (meta-analysis) of RT-fMRI-NF effectiveness on various psychiatric disorders and 3) methodological suggestions for future studies. Thirty-one clinical trials focusing on psychiatric disorders were included and categorized according to standard diagnostic categories. Neurofeedback using (RT-fMRI-NF) is an innovative technique that allows to voluntarily modulate a targeted brain response and its associated behavior. Despite promising results in the current literature, its effectiveness on symptoms management in psychiatric disorders is not yet clearly demonstrated. Among the 31 identified studies, 22 consisted of controlled trials, of which only eight showed significant clinical improvement in the experimental vs. control group after the training. Nine studies found an effect at follow-up on ADHD symptoms, emotion dysregulation, facial emotion processing, depressive symptoms, hallucinations, psychotic symptoms, and specific phobia. Within-group meta-analysis revealed large effects of the NF training on depressive symptoms right after the training and at follow-up, as well as medium effects on anxiety and emotion regulation. Between-group meta-analysis showed a medium effect on depressive symptoms and a large effect on anxiety. However, the between-studies heterogeneity is very high. The use of RT-fMRI-NF as a treatment for psychiatric symptoms is promising, however, further double-blind, multicentric, randomized-controlled trials are warranted to determine effectiveness.

Rahmani et al. (2022) evaluated the evidences related to the effectiveness of neurofeedback treatment for children and adolescent with attention-deficit/hyperactivity disorder (ADHD). A systematic review of randomized control trials (RCTs) was carried out across multiple databases. the primary outcome measure was the most proximal ratings of ADHD symptoms in subjects. Conner's Parent Rating Scale (CPRS), Conner's Teacher Rating Scale (CTRS), and ADHD Rating Scale (ADHD-RS- are considered as primary outcomes. Seventeen trials met inclusion criteria (including 1211 patients). Analysis showed that there was no significant benefit of neurofeedback treatment compared with other treatments or control. The results provide preliminary evidence that neurofeedback treatment is not an efficacious clinical method for ADHD and suggest that more RTCs are needed to compare common treatment.

Lin et al. (2022) sought to elucidate possible additive effects of electroencephalogram-based neurofeedback (EEG-NF) on medications against the core symptoms of attention-deficit/hyperactivity disorder (ADHD). The primary outcomes were changes in ADHD symptoms (i.e., global, inattention, hyperactivity/impulsivity) assessed with validated rating scales, while secondary outcome was all-cause discontinuation rate. Meta-analysis of five RCTs involving 305 participants with a median follow-up of 12 weeks showed additive effects of EEG-NF on medications from parents' observations against ADHD global symptoms and inattention symptoms. However,



additive effects failed to sustain six months after EEG-NF intervention. Besides, there was no difference in improvement of hyperactivity/impulsivity from parents' observation, attentional performance, and all-cause discontinuation rate between the two groups. Authors state their results supported additional benefits of combining EEG-NF with medications compared to medication alone in treating global symptoms and symptoms of inattention in ADHD patients. However, given a lack of evidence showing a correlation between underlying physiological changes and small effect sizes in these preliminary results, further studies are warranted to support our findings.

Patil et al. (2023) summarized the recent literature on electroencephalogram-neurofeedback (EEG-NF) training for treating depression in a systematic review. Conventional interventions to treat depression include long-term pharmacotherapy and cognitive behavioral therapy. Electroencephalogram-neurofeedback (EEG-NF) training has been suggested as a non-invasive option to treat depression with minimal side effects. The 12 studies included in the final sample reported that despite several issues related to EEG-NF practices, patients with depression showed significant cognitive, clinical, and neural improvements following EEG-NF training. Given its low cost and the low risk of side effects due to its non-invasive nature, authors suggest that EEG-NF is worth exploring as an augmented tool for patients who already receive standard medications but remain symptomatic, and that EEG-NF training may be an effective intervention tool that can be utilized as a supplementary treatment for depression. Authors also suggest that improvement of experimental designs and standards related to EEG-NF training practices for treating depression are needed.

Askovic et al. (2023) conducted a systematic review and meta-analysis of ten clinical trials to answer the question: how effective is NFB in addressing PTSD and other associated symptoms across different trauma populations, and are these improvements related to neurophysiological changes? Ten controlled studies were included; seven RCTs and three NRSIs with a total number of participants  $n = 293$  (128 male). Only RCTs were included in the meta-analysis (215 participants; 88 male). All included studies showed an advantage of NFB over control conditions in reducing symptoms of PTSD, with indications of improvement in symptoms of anxiety and depression and related neurophysiological changes. Meta-analysis of the pooled data shows a significant reduction in PTSD symptoms post-treatment, and the mean remission rate was higher in the NFB group (79.3%) compared to the control group (24.4%). However, the studies reviewed were mostly small, with heterogeneous populations and varied quality. Authors concluded that the effect of NFB on the symptoms of PTSD was moderate and mechanistic evidence suggested that NFB leads to therapeutic changes in brain functioning. Future research should focus on more rigorous methodological designs, expanded sample size and longer follow-up.

Saif and Sushkova (2024) examined the effect of different training protocols on the efficacy of neurofeedback in the treatment of ADHD across specific research studies published between 2017 and 2022. Altogether, a total of 916 records were identified and 18 articles met the inclusion criteria. Findings show that the efficacy of different neurofeedback protocols has been comparable to the efficacy of stimulant medications. Nevertheless, there is still room for more clinical trials on neurofeedback protocols for ADHD since some studies suggest not using neurofeedback as a stand-alone treatment for ADHD.

Xia et al. (2024) conducted a comprehensive meta-analysis to evaluate the efficacy of neurofeedback as a treatment for major depressive disorders. They conducted a comprehensive meta-analysis of 22 studies investigating the effects of neurofeedback interventions on depression symptoms, neurophysiological outcomes, and neuropsychological function. Their findings revealed that neurofeedback intervention had a significant impact on depression symptoms and neurophysiological outcomes. Authors also observed a moderate effect size for neurofeedback intervention on neuropsychological function. They also observed that longer intervention length was associated with better outcomes for depressive symptoms and neuropsychological function. Additionally they noted that shorter neurofeedback sessions were associated with improvements in neurophysiological outcomes. Authors conclude that their meta-analysis provides compelling evidence that neurofeedback holds promising potential as a non-pharmacological intervention option for effectively improving depressive symptoms, neurophysiological outcomes, and neuropsychological function in individuals with major depressive disorders.

Westwood et al. (2025) conducted a meta-analysis of randomized clinical trials (RCTs) using probably blinded (i.e., rated by individuals probably or certainly unaware of treatment allocation) or neuropsychological outcomes to test the efficacy of neurofeedback as a treatment for ADHD in terms of core symptom reduction and improved neuropsychological outcomes. The primary outcome was ADHD total symptom severity assessed at the first postintervention time point, focusing on reports by individuals judged probably or certainly unaware of treatment allocation (probably blinded). Secondary outcomes were inattention and/or hyperactivity-impulsivity symptoms

and neuropsychological outcomes postintervention and at a longer-term follow-up (i.e., after the last follow-up time point). A total of 38 RCTs (2472 participants aged 5 to 40 years) were included. Probably blinded reports of ADHD total symptoms showed no significant improvement with neurofeedback. A small significant improvement was seen when analyses were restricted to RCTs using established standard protocols. Results remained similar with adults being excluded or when analyses were restricted to RCTs where cortical learning or self-regulation was established. Of the 5 neuropsychological outcomes analyzed, a significant but small improvement was observed only for processing speed. Heterogeneity was generally low to moderate. Authors concluded that overall, neurofeedback did not appear to meaningfully benefit individuals with ADHD, clinically or neuropsychologically, at the group level. Future studies seeking to identify individuals with ADHD who may benefit from neurofeedback could focus on using standard neurofeedback protocols, measuring processing speed, and leveraging advances in precision medicine, including neuroimaging technology.

### **Home Biofeedback Devices**

Biofeedback should be performed in a clinical setting by trained professionals. The evidence in the published peer-reviewed scientific literature does not support the effectiveness of home electronic biofeedback devices. In some instances the results of clinical trials were limited due to the inability to monitor the use of home biofeedback used by subjects in the trial.

Cross et al. (2023) investigated and compared the efficacy of supervised Kegel exercises with bio-feedback on stress urinary incontinence (SUI) and pelvic floor muscle strength (PFMS) compared with unsupervised Kegel exercises. This was a matched-group quasi-experimental study of 29 female participants divided into two groups (supervised and non-supervised) and was conducted over 12 weeks. Baseline measurements of PFMS were undertaken by a women's health physiotherapist and a Kegel exercise regime bespoke designed for each participant. The supervised group visited the physiotherapist monthly for bio-feedback training (BT); the unsupervised group continued at home with their individualised Kegel exercises. Data were collected via a perineometer (Peritron™) and self-reporting responses to questionnaires. All participants received a final PFMS measurement on completion of the study. Results demonstrated that the overall Incontinence Severity index (ISI) score was significantly lower in the supervised group post-intervention. Wilcoxon signed-rank tests indicated that supervised Kegel exercises significantly reduced frequency ( $p=0.002$ ) and severity ( $p=0.020$ ) of overall ISI. Analysis of PFMS were not significantly different, despite an increase in maximum voluntary contraction or pelvic floor muscle strength (PFMS) ( $p=0.032$ ) in the supervised group. Of the questionnaires, results of Wilcoxon signed-rank tests indicated that "total bother" was significantly reduced ( $p=0.005$ ) in the supervised group. The correlation analysis between PFMS and ISI did not reveal any significant results. Authors concluded that the study confirmed that supervised BT is more effective in reducing SUI than unsupervised Kegel exercises, and that this reduction in ISI score did not correlate with the improvement in PFMS.

Peirce et al. (2013) conducted a randomized controlled trial ( $n=120$ ) to determine if home biofeedback alone would have better anal manometry results at three months postpartum compared to pelvic floor exercises (PFEs) alone in women who sustained a primary third-degree postpartum tear. The secondary outcome criterion was improvement in continence scores. Subjects were randomized to home biofeedback ( $n=30$ ) (CombiStim XP, Neurotech®, Galway, Ireland) or conventional PFEs ( $n=90$ ). At the three month follow-up, there was no significant difference in anal resting ( $p=0.123$ ), squeeze pressure ( $p=0.68$ ), and the Cleveland Clinic continence scores ( $p=0.88$ ) between the groups. There were no significant differences in the Rockwood fecal incontinence quality of life scale score including: lifestyle ( $p=0.29$ ), coping ( $p=0.27$ ), depression ( $p=0.89$ ) and embarrassment ( $p=0.51$ ). Seven of the 30 biofeedback subjects reported poor adherence. Home biofeedback did not improve the clinical outcomes of this subpopulation of women. Limitations of the study include the small patient population and short-term follow-up.

An earlier randomized controlled trial compared the use of anorectal manometry EMG biofeedback performed in a laboratory ( $n=24$ ) to EMG biofeedback performed in the home ( $n=12$ ) for children with chronic constipation who had failed conventional treatment. The outcomes indicated that no additional benefit was gained by the use of home biofeedback (Croffie, et al., 2005). A randomized controlled trial by Aukee et al. (2004) reported that 11 of 16 women who received 12 weeks of home EMG-assisted biofeedback (FemiScan™, MegaElectronics, Kuopio, Finland) avoided surgical intervention compared to ten of 19 control subjects who did not use home biofeedback.

In a 2002 decision memo regarding the use of home biofeedback for urinary incontinence, the Centers for Medicare and Medicaid (2002), stated that "the scientific evidence is not adequate to conclude that the use of home biofeedback devices for the treatment of urinary incontinence is clinically effective, and, therefore, is

not reasonable and necessary for treating urinary incontinence or to improve the functioning of a malformed body member”.

Wang et al. (2024) compared the efficacy of PFMT with or without a home-based pressure-mediated biofeedback (BF) device. Participants included eligible women with new-onset postpartum SUI who were enrolled from March 28, 2022, to October 13, 2023. All participants received 3 months of supervised PFMT and were randomized to either the intervention (PFMT with a home-based pressure-mediated BF device) or the control group (home-based PFMT). The primary outcome was the severity of urinary incontinence evaluated by the International Consultation on Incontinence Questionnaire-Urinary Incontinence Short Form after 3 months of supervised PFMT. The secondary outcomes included the cure and improvement rates, PFM strength, quality of life, self-efficacy, and adherence. A total of 452 participants were included in the analysis, with 223 in the intervention group and 229 in the control group. Compared with the control group, the intervention group achieved a significantly greater reduction in incontinence severity, significantly increased cure rate and improvement, significantly greater pelvic floor muscle strength, and a significantly greater correlation between subjective and objective adherence. Authors concluded that in this randomized clinical trial, the efficacy of pressure-mediated BF combined with PFMT was superior to that of PFMT alone.

### **InTandem Neurorehabilitation System**

InTandem is indicated to improve walking and ambulation in adult chronic stroke patients in a home setting. Presently, the evidence in the published peer-reviewed scientific literature does not support the effectiveness of this system over standard clinic and home rehabilitation interventions.

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## **References**

1. Ainoosah S, Farghal AE, Alzemei MS, et al. Comparative analysis of different types of occlusal splints for the management of sleep bruxism: a systematic review. *BMC Oral Health*. 2024;24(1):29. Published 2024 Jan 5. doi:10.1186/s12903-023-03782-6
2. Alouini S, Memic S, Couillandre A. Pelvic Floor Muscle Training for Urinary Incontinence with or without Biofeedback or Electrostimulation in Women: A Systematic Review. *Int J Environ Res Public Health*. 2022;19(5):2789. Published 2022 Feb 27. doi:10.3390/ijerph19052789
3. American Academy of Pediatrics (AAP). Mental health initiatives. Mental Health Practice Tools and Resources. Retrieved on September 4, 2025 from <https://www.aap.org/en/patient-care/mental-health-initiatives/mental-health-practice-tools-and-resources/>
4. American Cancer Society. Pain Control: Non-medical treatments for pain. Retrieved on September 4, 2025 from <https://www.cancer.org/cancer/managing-cancer/side-effects/pain/non-medical-treatments-for-cancer-pain.html>
5. American College of Physicians (ACP). Noninvasive Treatments for Acute, Subacute, and Chronic Low Back Pain: A Clinical Practice Guideline from the American College of Physicians. 2017. Retrieved on September 4, 2025 from <https://www.acpjournals.org/doi/pdf/10.7326/M16-2367>
6. American Congress of Obstetricians and Gynecologists (ACOG). Committee on Gynecologic Practice. ACOG Committee Opinion: Number 673: Persistent vulvar pain. Oct 2006. Reaffirmed 2024. Retrieved on September 4, 2025 from <https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2016/09/persistent-vulvar-pain>
7. American Gastroenterological Association, Bharucha AE, Dorn SD, Lembo A, Pressman A. American Gastroenterological Association medical position statement on constipation. *Gastroenterology*. 2013;144(1):211-217. doi:10.1053/j.gastro.2012.10.029
8. American Society of Anesthesiologists Task Force on Chronic Pain Management; American Society of Regional Anesthesia and Pain Medicine. Practice guidelines for chronic pain management: an updated

report by the American Society of Anesthesiologists Task Force on Chronic Pain Management and the American Society of Regional Anesthesia and Pain Medicine. *Anesthesiology*. 2010 Apr;112(4):810-33.

9. American Society of Colon and Rectal Surgeons. Clinical practice guideline for the treatment of fecal incontinence. 2023. Retrieved on September 4, 2025 from <https://www.fascrs.org/physicians/clinical-practice-guidelines>
10. American Society of Colon and Rectal Surgeons. Clinical practice guideline for the evaluation and management of constipation. 2016. Retrieved on September 4, 2025 from <https://www.fascrs.org/physicians/clinical-practice-guidelines>
11. Ananías J, Vidal C, Ortiz-Muñoz L, Irrarázaval S, Besa P. Use of electromyographic biofeedback in rehabilitation following anterior cruciate ligament reconstruction: a systematic review and meta-analysis. *Physiotherapy*. 2024;123:19-29. doi:10.1016/j.physio.2023.12.005
12. Angelakis E, Stathopoulou S, Frymiare JL, Green DL, Lubar JF, Kounios J. EEG neurofeedback: a brief overview and an example of peak alpha frequency training for cognitive enhancement in the elderly. *Clin Neuropsychol*. 2007 Jan;21(1):110-29.
13. Askovic M, Soh N, Elhindi J, Harris AWF. Neurofeedback for post-traumatic stress disorder: systematic review and meta-analysis of clinical and neurophysiological outcomes. *Eur J Psychotraumatol*. 2023;14(2):2257435. doi:10.1080/20008066.2023.2257435
14. Astin JA, Beckner W, Soeken K, Hochberg MC, Berman B. Psychological interventions for rheumatoid arthritis: a meta-analysis of randomized controlled trials. *Arthritis Rheum*. 2002;47(3):291-302.
15. Aukee P, Immonen P, Laaksonen DE, Laippala P, Penttinen J, Airaksinen O. The effect of home biofeedback training on stress incontinence. *Acta Obstet Gynecol Scand*. 2004 Oct;83(10):973-7.
16. Awad LN, Jayaraman A, Nolan KJ, et al. Efficacy and safety of using auditory-motor entrainment to improve walking after stroke: a multi-site randomized controlled trial of InTandemTM. *Nat Commun*. 2024;15(1):1081. Published 2024 Feb 8. doi:10.1038/s41467-024-44791-5
17. Babu AS, Mathew E, Danda D, Prakash H. Management of patients with fibromyalgia using biofeedback: A randomized control trial. *Indian J Med Sci* 2007;61:455-61.
18. Balbinot G, Joner Wiest M, Li G, et al. The use of surface EMG in neurorehabilitation following traumatic spinal cord injury: A scoping review. *Clin Neurophysiol*. 2022;138:61-73. doi:10.1016/j.clinph.2022.02.028
19. Barragán Loayza IM, Solà I, Juandó PratsC. Biofeedback for pain management during labour. *CochraneDatabase of Systematic Reviews* 2011, Issue 6. Art. No.: CD006168. DOI: 10.1002/14651858.CD006168.pub2.
20. Baumann FT, Reimer N, Gockeln T, et al. Supervised pelvic floor muscle exercise is more effective than unsupervised pelvic floor muscle exercise at improving urinary incontinence in prostate cancer patients following radical prostatectomy – a systematic review and meta-analysis [published online ahead of print, 2021 Sep 22]. *Disabil Rehabil*. 2021;1-12
21. Bergeron S, Binik YM, Khalife S, Pagidas K, Glazer HI, Meana M, Amsel R. A randomized comparison of group cognitive behavioral therapy, surface electromyographic biofeedback, and vestibulectomy in the treatment of dyspareunia resulting from vulvar vestibulitis. *Pain*. 2001 Apr;91(3):297-306.
22. Burgio KL, Goode PS, Locher JL, Umlauf MG, Roth DL, Richter HE, Varner RE, Lloyd LK. Behavioral training with and without biofeedback in the treatment of urge incontinence in older women: a randomized controlled trial. *JAMA*. 2002 Nov 13;288(18):2293-9.

23. Burgio KL, Goode PS, Urban DA, Umlauf MG, Locher JL, Bueschen A, Redden DT. Preoperative biofeedback assisted behavioral training to decrease post-prostatectomy incontinence: a randomized, controlled trial. *J Urol*. 2006 Jan;175(1):196-201; discussion 201.
24. Burlacu A, Brinza C, Popa IV, Covic A, Floria M. Influencing Cardiovascular Outcomes through Heart Rate Variability Modulation: A Systematic Review. *Diagnostics (Basel)*. 2021;11(12):2198. Published 2021 Nov 25.
25. Bussadori SK, Motta LJ, Horliana ACRT, Santos EM, Martimbianco ALC. The Current Trend in Management of Bruxism and Chronic Pain: An Overview of Systematic Reviews. *J Pain Res*. 2020 Sep 30;13:2413-2421. doi: 10.2147/JPR.S268114.
26. Busse JW, Casassus R, Carrasco-Labra A, et al. Management of chronic pain associated with temporomandibular disorders: a clinical practice guideline. *BMJ*. 2023;383:e076227. Published 2023 Dec 15. doi:10.1136/bmj-2023-076227
27. Brasileiro A, Gama G, Trigueiro L, Ribeiro T, Silva E, Galvão É, Lindquist A. Influence of visual and auditory biofeedback on partial body weight support treadmill training of individuals with chronic hemiparesis: a randomized controlled clinical trial. *Eur J Phys Rehabil Med*. 2015 Feb;51(1):49-58.
28. Brazzelli M, Griffiths P. Behavioural and cognitive interventions with or without other treatments for the management of faecal incontinence in children. *Cochrane Database Syst Rev*. 2006 Apr 19;(2):CD002240.
29. Brazzelli M, Griffiths PV, Cody JD, Tappin D. Behavioural and cognitive interventions with or without other treatments for the management of faecal incontinence in children. *Cochrane Database of Systematic Reviews* 2011, Issue 12. Art. No.: CD002240. DOI: 10.1002/14651858.CD002240.pub4.
30. Brook RD, Appel LJ, Rubenfire M, Ogedegbe G, Bisognano JD, Elliott WJ, Fuchs FD, Hughes JW, Lackland DT, Staffileno BA, Townsend RR, Rajagopalan S; American Heart Association Professional Education Committee of the Council for High Blood Pressure Research, Council on Cardiovascular and Stroke Nursing, Council on Epidemiology and Prevention, and Council on Nutrition, Physical Activity. Beyond medications and diet: alternative approaches to lowering blood pressure: a scientific statement from the American Heart Association. *Hypertension*. 2013 Jun;61(6):1360-83.
31. Brown HW, Dyer KY, Rogers RG. Management of Fecal Incontinence. *Obstet Gynecol*. 2020 Oct;136(4):811-822. doi: 10.1097/AOG.0000000000004054.
32. Brunnhuber K, Nash S, Meier DE, Weissman DE, Woodcock J. Putting evidence into practice: palliative care. *BMJ* 2008;1-88.
33. Campo M, Zadro JR, Pappas E, Monticone M, Secci C, Scalzitti D, Findley JL, Graham PL. The effectiveness of biofeedback for improving pain, disability and work ability in adults with neck pain: A systematic review and meta-analysis. *Musculoskelet Sci Pract*. 2021 Jan 8;52:102317. doi: 10.1016/j.msksp.2021.102317.
34. Centers for Medicare and Medicaid (CMS). Decision memo for home biofeedback for urinary incontinence (CAG-00118N). Mar 1, 2002. Retrieved September 4, 2025 from <https://www.cms.gov/medicare-coverage-database/details/nca-decision-memo.aspx?NCAId=34&SearchType=Advanced&CoverageSelection=National&NCSelection=NCA%7cCAL%7cNCD%7cMEDCAC%7cTA%7cMCD&KeyWord=biofeedback&KeyWordLookUp=Title&KeyWordSearchType=Exact&kq=true&bc=IAAAACAACAAAAA%3d%3d&>
35. Centers for Medicare and Medicaid Services (CMS). National Coverage Determination (NCD) for Biofeedback Therapy (30.1). Retrieved on September 4, 2025 from <https://www.cms.gov/medicare-coverage-database/details/ncd-details.aspx?NCDId=41&ncdver=1&CoverageSelection=Both&ArticleType=All&PolicyType=Final&CptHcpcsCode=93010&bc=gAAAACAAAAA%3d%3d&>

36. Chiarioni G, Nardo A, Vantini I, Romito A, Whitehead WE. Biofeedback is superior to electrogalvanic stimulation and massage for treatment of levator ani syndrome. *Gastroenterology*. 2010 Apr;138(4):1321-9.
37. Chiarioni G, Whitehead WE, Pezza V, Morelli A, Bassotti G. Biofeedback is superior to laxatives for normal transit constipation due to pelvic floor dyssynergia. *Gastroenterology*. 2006 Mar;130(3):657-64.
38. Coben R, Linden M, Myers TE. Neurofeedback for autistic spectrum disorder: a review of the literature. *Appl Psychophysiol Biofeedback*. 2010 Mar;35(1):83- 105.
39. Crider A, Glaros AG, Gevirtz RN. Efficacy of biofeedback-based treatments for temporomandibular disorders. *Appl Psychophysiol Biofeedback*. 2005 Dec;30(4):333-45.
40. Croffie JM, Ammar MS, Pfefferkorn MD, Horn D, Klipsch A, Fitzgerald JF, Gupta SK, Molleston JP, Corkins MR. Assessment of the effectiveness of biofeedback in children with dyssynergic defecation and recalcitrant constipation/encopresis: does home biofeedback improve long-term outcomes. *Clin Pediatr (Phila)*. 2005 Jan-Feb;44(1):63-71.
41. Cross D, Waheed N, Krake M, Gahreman D. Effectiveness of supervised Kegel exercises using bio-feedback versus unsupervised Kegel exercises on stress urinary incontinence: a quasi-experimental study. *Int Urogynecol J*. 2023;34(4):913-920. doi:10.1007/s00192-022-05281-8
42. Dannecker C, Wolf V, Raab R, Hepp H, Anthuber C. EMG-biofeedback assisted pelvic floor muscle training is an effective therapy of stress urinary or mixed incontinence: a 7-year experience with 390 patients. *Arch Gynecol Obstet*. 2005 Dec;273(2):93-7.
43. Department of Veterans Affairs. VA/DOD clinical practice guideline for the management of stroke rehabilitation. 2024. Retrieved on September 4, 2025 from <http://www.healthquality.va.gov/index.asp>
44. Desantis DJ, Leonard MP, Preston MA, Barrowman NJ, Guerra LA. Effectiveness of biofeedback for dysfunctional elimination syndrome in pediatrics: a systematic review. *J Pediatr Urol*. 2011 Jun;7(3):342-8.
45. Doğan-Aslan M, Nakipoğlu-Yüzer GF, Doğan A, Karabay I, Özgirgin N. The effect of electromyographic biofeedback treatment in improving upper extremity functioning of patients with hemiplegic stroke. *J Stroke Cerebrovasc Dis*. 2012 Apr;21(3):187-92.
46. Dohrmann K, Weisz N, Schlee W, Hartmann T, Elbert T. Neurofeedback for treating tinnitus. *Prog Brain Res*. 2007;166:473-85.
47. Drużbicki M, Guzik A, Przysada G, Kwolek A, Brzozowska-Magoń A. Efficacy of gait training using a treadmill with and without visual biofeedback in patients after stroke: A randomized study. *J Rehabil Med*. 2015 May;47(5):419-25.
48. EEG Education and Research Inc. Neurofeedback. Retrieved on September 4, 2025 from <https://www.eeger.com/>
49. Ehrenborg C, Archenholtz B. Is surface EMG biofeedback an effective training method for persons with neck and shoulder complaints after whiplash-associated disorders concerning activities of daily living and pain – a randomized controlled trial. *Clin Rehabil*. 2010 Aug;24(8):715-26.
50. Elavally S, Ramamurthy MT, Subash J, Meleveedu R, Venkatasalu MR. Effect of nurse-led home-based biofeedback intervention on the blood pressure levels among patients with hypertension: Pretest-posttest study. *J Family Med Prim Care*. 2020 Sep 30;9(9):4833-4840. doi: 10.4103/jfmpc.jfmpc\_210\_20.

51. Enck P, van der Voort IR, Klosterhalfen S. Biofeedback therapy in fecal incontinence and constipation. *Neurogastroenterol Motil.* 2009 Jun 30.
52. Erickson BA, Schaeffer AJ, Van Le B. Chronic prostatitis. *Clin Evid (Online).* 2008 May 22;2008. pii: 1802.
53. Eslamian F, Jahanjoo F, Dolatkhah N, Pishgahi A, Pirani A. Relative Effectiveness of Electroacupuncture and Biofeedback in the Treatment of Neck and Upper Back Myofascial Pain: A Randomized Clinical Trial. *Arch Phys Med Rehabil.* 2020 May;101(5):770-780. doi: 10.1016/j.apmr.2019.12.009.
54. Fazeli MS1, Lin Y2, Nikoo N2, Jaggumantri S1, Collet JP1, Afshar K3. Biofeedback for nonneuropathic daytime voiding disorders in children: a systematic review and meta-analysis of randomized controlled trials. *J Urol.* 2015 Jan;193(1):274-9.
55. Feng S, Tang M, Huang G, et al. EMG biofeedback combined with rehabilitation training may be the best physical therapy for improving upper limb motor function and relieving pain in patients with the post-stroke shoulder-hand syndrome: A Bayesian network meta-analysis. *Front Neurol.* 2023;13:1056156. Published 2023 Jan 10. doi:10.3389/fneur.2022.1056156
56. Fernández-Alvarez J, Grassi M, Colombo D, et al. Efficacy of bio- and neurofeedback for depression: a meta-analysis. *Psychol Med.* 2022;52(2):201-216. doi:10.1017/S0033291721004396
57. Fernandes, A. C. N., Jorge, C. H., Weatherall, M., Ribeiro, I. V., Wallace, S. A., & Hay-Smith, E. J. C. (2025). Pelvic floor muscle training with feedback or biofeedback for urinary incontinence in women. *The Cochrane database of systematic reviews*, 3(3), CD009252. <https://doi.org/10.1002/14651858.CD009252.pub2>
58. Fitz FF, Resende AP, Stüpp L, Sartori MG, Girão MJ, Castro RA. Biofeedback for the treatment of female pelvic floor muscle dysfunction: a systematic review and meta-analysis. *Int Urogynecol J.* 2012 Mar 17.Foy JM, Green CM, Earls MF , AAP committee on psychosocial aspects of child and family health, mental health leadership work group. *Mental Health Competencies for Pediatric Practice. Pediatrics.* 2019;144(5):e20192757
59. Fournié C, Chouchou F, Dalleau G, Caderby T, Cabrera Q, Verkindt C. Heart rate variability biofeedback in chronic disease management: A systematic review. *Complement Ther Med.* 2021;60:102750.
60. Fuchs T, Birbaumer N, Lutzenberger W, Gruzelier JH, Kaiser J. Neurofeedback treatment for attention-deficit/hyperactivity disorder in children: a comparison with methylphenidate. *Appl Psychophysiol Biofeedback.* 2003 Mar;28(1):1-12.
61. Giggins OM, Persson UM, Caulfield B. Biofeedback in rehabilitation. *J Neuroeng Rehabil.* 2013 Jun 18;10:60.
62. Gladstein J. Headache. *Med Clin North Am.* 2006 Mar;90(2):275-90.
63. Glasscoe CA, Quittner AL. Psychological interventions for people with cystic fibrosis and their families. *Cochrane Database Syst Rev.* 2008 Jul 16;(3):CD003148.
64. Glatke KE, Tummala SV, Chhabra A. Anterior Cruciate Ligament Reconstruction Recovery and Rehabilitation: A Systematic Review. *J Bone Joint Surg Am.* 2022;104(8):739-754. Doi:10.2106/JBJS.21.00688
65. Goldenberg JZ, Brignall M, Hamilton M, Beardsley J, Batson RD, Hawrelak J, Lichtenstein B, Johnston BC. Biofeedback for treatment of irritable bowel syndrome. *Cochrane Database Syst Rev.* 2019 Nov 12;2019(11):CD012530.

66. Greenhalgh J, Dickson R, Dundar Y. The effects of biofeedback for the treatment of essential hypertension: a systematic review. *Health Technol Assess.* 2009 Oct;13(46):1-104
67. Haefner HK, Collins ME, Davis GD, Edwards L, Foster DC, Hartmann ED, Kaufman RH, Lynch PJ, Margesson LJ, Moyal-Barracco M, Piper CK, Reed BD, Stewart EG, Wilkinson EJ. The vulvodynia guideline. *J Low Genit Tract Dis.* 2005 Jan;9(1):40-51.
68. Hagen S, Elders A, Stratton S, Sergenson N, Bugge C, Dean S, Hay-Smith J, Kilonzo M, Dimitrova M, Abdel-Fattah M, Agur W, Booth J, Glazener C, Guerrero K, McDonald A, Norrie J, Williams LR, McClurg D. Effectiveness of pelvic floor muscle training with and without electromyographic biofeedback for urinary incontinence in women: multicentre randomized controlled trial. *BMJ.* 2020 Oct 14;371:m3719. doi: 10.1136/bmj.m3719.
69. Harris RP, Helfand M, Woolf SH, et al. Current methods of the US Preventive Services Task Force: a review of the process. *Am J Prev Med.* 2001; 20:21–35.
70. Heinrich H, Gevensleben H, Strehl U. Annotation: neurofeedback – train your brain to train behaviour. *J Child Psychol Psychiatry.* 2007 Jan;48(1):3-16.
71. Hayes Inc. Search and Summary. Biofeedback for Spastic Torticollis. Lansdale, PA: Sept 15, 2016.
72. Hayes Inc. Search and Summary. Biofeedback for the treatment of dysfunctional voiding in children. Lansdale, PA: Jun 16, 2016.
73. Hayes Inc. Hayes Update Search™. Electroencephalogram (EEG) Biofeedback Therapy. Lansdale, PA: Mar 13, 2008.
74. Henschke N, Ostelo RWJG, van Tulder MW, Vlaeyen JWS, Morley S, Assendelft WJJ, Main CJ. Behavioural treatment for chronic low-back pain. *Cochrane Database of Systematic Reviews* 2010, Issue 7. Art. No.: CD002014. DOI:10.1002/14651858.CD002014.pub3.
75. Herbison GP, Dean N. Weighted vaginal cones for urinary incontinence. *Cochrane Database Syst Rev.* 2013 Jul 8;2013(7):CD002114. doi: 10.1002/14651858.CD002114.pub2. PMID: 23836411; PMCID: PMC7086390. Herderschee R, Hay-Smith EJC, Herbison GP, Roovers JP, Heineman MJ. Feedback or biofeedback to augment pelvic floor muscle training for urinary incontinence in women. *Cochrane Database of Systematic Reviews* 2011, Issue 7. Art. No.: CD009252. DOI:10.1002/14651858.CD009252.
76. Hesam-Shariati N, Chang WJ, Wewege MA, et al. The analgesic effect of electroencephalographic neurofeedback for people with chronic pain: A systematic review and meta-analysis. *Eur J Neurol.* 2022;29(3):921-936. doi:10.1111/ene.15189
77. Heymen S, Scarlett Y, Jones K, Ringel Y, Drossman D, Whitehead WE. Randomized, controlled trial shows biofeedback to be superior to alternative treatments for patients with pelvic floor dyssynergia-type constipation. *Dis Colon Rectum.* 2007 Apr;50(4):428-41.
78. Heymen S, Jones KR, Scarlett Y, Whitehead WE. Biofeedback treatment of constipation: a critical review. *Dis Colon Rectum.* 2003 Sep;46(9):1208-17.
79. Hite M, Curran T. Biofeedback for Pelvic Floor Disorders. *Clin Colon Rectal Surg.* 2021 Jan;34(1):56-61. doi: 10.1055/s-0040-1714287.
80. Hjelland IE, Svebak S, Berstad A, Flatabø G, Hausken T. Breathing exercises with vagal biofeedback may benefit patients with functional dyspepsia. *Scand J Gastroenterol.* 2007 Sep;42(9):1054-62.
81. Höder A, Stenbeck J, Fernando M, Lange E. Pelvic floor muscle training with biofeedback or feedback from a physiotherapist for urinary and anal incontinence after childbirth - a systematic review. *BMC Womens Health.* 2023 Nov 18;23(1):618.



82. Holroyd KA, Mauskop A. Complementary and alternative treatments. *Neurology*. 2003 Apr 8;60(7).
83. Holroyd-Leduc JM, Tannenbaum C, Thorpe KE, Straus SE. What type of urinary incontinence does this woman have? *JAMA*. 2008 Mar 26;299(12):1446-56.
84. Holtmann M, Stadler C. Electroencephalographic biofeedback for the treatment of attention-deficit hyperactivity disorder in childhood and adolescence. *Expert Rev Neurother*. 2006 Apr;6(4):533-40.
85. Huffman J, Sakonju A. Chapter 19 – Neurology. Differential diagnosis of recurrent or chronic headaches. In: Johns Hopkins: The Harriet Lane Handbook: A Manual for Pediatric House Officers, 17th ed. Philadelphia. Mosby's, 2005.
86. Hunter KF, Moore KN, Cody DJ, Glazener CM. Conservative management for postprostatectomy urinary incontinence. *Cochrane Database Syst Rev*. 2004;(2):CD001843.
87. Illyckyj A, Fachnie E, Tougas G. A randomized-controlled trial comparing an educational intervention alone vs education and biofeedback in the management of faecal incontinence in women. *Neurogastroenterol Motil*. 2005 Feb;17(1):58-63.
88. Italian Society of Colorectal Surgery (SICCR), Pucciani F, Altomare DF, Dodi G, Falletto E, Frasson A, Giani I, Martellucci J, Naldini G, Piloni V, Sciaudone G; Italian Association of Hospital Gastroenterologists (AIGO), Bove A, Bocchini R, Bellini M, Alduini P, Battaglia E, Galeazzi F, Rossitti P, Usai Satta P. Diagnosis and treatment of faecal incontinence: Consensus statement of the Italian Society of Colorectal Surgery and the Italian Association of Hospital Gastroenterologists. *Dig Liver Dis*. 2015 Aug;47(8):628-45.
89. Jacobsen LV, Jørgensen CS, Kaas Sørensen KM, Enemark L, Rittig S, Kamperis K. The efficacy of physiotherapeutic intervention with biofeedback assisted pelvic floor muscle training in children with dysfunctional voiding. *J Pediatr Urol*. 2021;17(6):793.e1-793.e6.
90. Johnson EE, Mamoulakis C, Stoniute A, Omar MI, Sinha S. Conservative interventions for managing urinary incontinence after prostate surgery. *Cochrane Database Syst Rev*. 2023;4(4):CD014799. Published 2023 Apr 18. doi:10.1002/14651858.CD014799.pub2
91. Jokubauskas L, Baltrušaitytė A. Efficacy of biofeedback therapy on sleep bruxism: A systematic review and meta-analysis. *J Oral Rehabil*. 2018 Jun;45(6):485-495. doi: 10.1111/joor.12628. Epub 2018 Apr 11.
92. Jones L, Othman M, Dowswell T, Alfirevic Z, Gates S, Newburn M, Jordan S, Lavender T, Neilson JP. Pain management for women in labour: an overview of systematic reviews. *Cochrane Database of Systematic Reviews* 2012, Issue 3. Art. No.: CD009234. DOI: 10.1002/14651858.CD009234.pub2.
93. Karaborklu Argut S, Celik D, Yasaci Z. Effectiveness of therapeutic electromyographic biofeedback after orthopedic knee surgeries: a systematic review. *Disabil Rehabil*. 2022;44(14):3364-3372. Doi:10.1080/09638288.2020.1867904.
94. Karjalainen K, Malmivaara A, van Tulder M, Roine R, Jauhiainen M, Hurri H, et al. Biopsychosocial rehabilitation for upper limb repetitive strain injuries in working age adults. *The Cochrane Review*. In: The Cochrane Library, Issue 3, 2000. Update Dec 2004. Chichester, UK: John Wiley & sons, Ltd.; 2004. Oxford: Update software.
95. Karmody CS. Alternative therapies in the management of headache and facial pain. *Otolaryngol Clin N Am*. 2003;36:1221–30.
96. Kaushik R, Kaushik RM, Mahajan SK, Rajesh V. Biofeedback assisted diaphragmatic breathing and systematic relaxation versus propranolol in long term prophylaxis of migraine. *Complement Ther Med*. 2005 Sep;13(3):165-74.

97. Khondker A, Ahmad I, Rajesh Z, et al. The Role of Secondary Conservative Management Strategies in Bladder and Bowel Dysfunction: A Systematic Review and Meta-analysis. *J Pediatr.* 2024;273:114152. doi:10.1016/j.jpeds.2024.114152
98. Kiresuk TJ, Trachtenberg A. Alternative and complementary health practices. Sadock BJ, Sadock VA, editors. In: Kaplan & Sadock's Comprehensive textbook of psychiatry. PA: Lippincott Williams & Wilkins. 2005.
99. Klijn AJ, Uiterwaal CS, Vijverberg MA, Winkler PL, Dik P, de Jong TP. Home uroflowmetry biofeedback in behavioral training for dysfunctional voiding in school-age children: a randomized controlled study. *J Urol.* 2006 Jun;175(6):2263-8; discussion 2268.
100. Kobashi KC, Vasavada S, Bloschichak A, et al. Updates to surgical treatment of female stress urinary incontinence (SUI): AUA/SUFU guideline (2023). *J Urol.* 2023;209(6):1091-1098.
101. Koh CE, Young CJ, Young JM, Solomon MJ. Systematic review of randomized controlled trials of the effectiveness of biofeedback for pelvic floor dysfunction. *Br J Surg.* 2008 Sep;95(9):1079-87.
102. Kuo LJ, Lin YC, Lai CH, Lin YK, Huang YS, Hu CC, Chen SC. Improvement of fecal incontinence and quality of life by electrical stimulation and biofeedback for patients with low rectal cancer after intersphincteric resection. *Arch Phys Med Rehabil.* 2015 Aug;96(8):1442-7.
103. Lacima G, Pera M, Amador A, Escaramís G, Piqué JM. Long-term results of biofeedback treatment for faecal incontinence: a comparative study with untreated controls. *Colorectal Dis.* 2009 Apr 10.
104. Ladi-Seyedian S, Kajbafzadeh AM, Sharifi-Rad L, Shadgan B, Fan E. Management of non-neuropathic underactive bladder in children with voiding dysfunction by animated biofeedback: a randomized clinical trial. *Urology.* 2015 Jan;85(1):205-10. doi: 10.1016/j.urology.2014.09.025
105. Lee YS, Bae SH, Lee SH, Kim KY. Neurofeedback training improves the dual-task performance ability in stroke patients. *Tohoku J Exp Med.* 2015;236(1):81-8.
106. Leonardo K, Seno DH, Mirza H, Afriansyah A. Biofeedback-assisted pelvic floor muscle training and pelvic electrical stimulation in women with overactive bladder: A systematic review and meta-analysis of randomized controlled trials. *Neurourol Urodyn.* 2022;41(6):1258-1269. Doi:10.1002/nau.24984
107. Li H, Guo C, Gao J, Yao H. Effectiveness of Biofeedback Therapy in Patients with Bowel Dysfunction Following Rectal Cancer Surgery: A Systemic Review with Meta-Analysis. *Ther Clin Risk Manag.* 2022;18:71-93. Published 2022 Feb 2.
108. Li RY, Chen KY, Wang XR, Yu Q, Xu L. Comparison of Different Rehabilitation Techniques of Traditional Chinese and Western Medicine in the Treatment of Motor Dysfunction After Stroke Based on Frequency Method: A Network Meta-analysis. *Am J Phys Med Rehabil.* 2023;102(6):504-512. doi:10.1097/PHM.0000000000002130
109. Li F, Feng L, Yang Y, Ma X, Kang T, Huang W. The effect of biofeedback on nonneurological dysfunctional voiding in children: A meta-analysis and systematic review. *J Pediatr Urol.* 2024;20(4):565-580. doi:10.1016/j.jpuro.2024.06.042
110. Lima KHM, Gomes JS, Tucci AM. Electroencephalographic neurofeedback as a tool for reducing harm and risk associated with alcohol use disorder: A critical review. *Drug Alcohol Rev.* 2022;41(3):594-602. doi:10.1111/dar.13387
111. Lin FL, Sun CK, Cheng YS, et al. Additive effects of EEG neurofeedback on medications for ADHD: a systematic review and meta-analysis. *Sci Rep.* 2022;12(1):20401. Published 2022 Nov 27. doi:10.1038/s41598-022-23015-0

112. Lirio-Romero C, Torres-Lacomba M, GómezLirio-Romero C, Torres-Lacomba M, Gómez-Blanco A, Acero-Cortés A, Retana-Garrido A, de la Villa-Polo P, Sánchez-Sánchez B. Electromyographic biofeedback improves upper extremity function: a randomized, single-blinded, controlled trial. *Physiotherapy*. 2021 Mar;110:54-62. doi: 10.1016/j.physio.2020.02.002.
113. Litvinas, I. Ch 31 – stroke (cerebrovascular disease). In: *Rakel: Integrative Medicine*, 2<sup>nd</sup> ed. Philadelphia: Saunders Elsevier, 2007.
114. Luctkar-Flude M, Groll D. A Systematic Review of the Safety and Effect of Neurofeedback on Fatigue and Cognition. *Integr Cancer Ther*. 2015 Jul;14(4):318-40.
115. Malik K, Dua A. Biofeedback. 2020 Mar 20. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan–. PMID: 31971716
116. Malenfant D, Catton M, Pope JE. The efficacy of complementary and alternative medicine in the treatment of Raynaud's phenomenon: a literature review and meta-analysis. *Rheumatology (Oxford)*. 2009 Jul;48(7):791-5.
117. Martino Cinnera A, Morone G, Bisirri A, Lucenti T, Rotundo M, Monaci S, Berton C, Paoluzzi M, Iosa M, Ciancarelli I. Headaches treatment with EMG biofeedback: a focused systematic review and meta-analysis. *Eur J Phys Rehabil Med*. 2023 Dec;59(6):697-705.
118. McConaghy JR. Headache in primary care. *Prim Care*. 2007 Mar;34(1):83-97.
119. McDonough-Means SI, Cohen MW. Chapter 11. Attention deficit disorder. In: *Rakel: Integrative Medicine*, 2<sup>nd</sup> ed. Philadelphia: Saunders Elsevier, 2007.
120. McGinnis RA, McGrady A, Cox SA, Grower-Dowling KA. Biofeedback-assisted relaxation in type 2 diabetes. *Diabetes Care*. 2005 Sep;28(9):2145-9.
121. McGrady A. The effects of biofeedback in diabetes and essential hypertension. *Cleve Clin J Med*. 2010 Jul;77 Suppl 3:S68-71.
122. McKee MG, Moravec CS. Biofeedback in the treatment of heart failure. *Cleve Clin J Med*. 2010 Jul;77 Suppl 3:S56-9.
123. Medlicott MS, Harris SR. A systematic review of the effectiveness of exercise, manual therapy, electrotherapy, relaxation training, and biofeedback in the management of temporomandibular disorder. *Phys Ther*. 2006 Jul;86(7):955-73.
124. Middaugh SJ, Haythornthwaite JA, Thompson B, Hill R, Brown KM, Freedman RR, Attanasio V, Jacob RG, Scheier M, Smith EA. The Raynaud's Treatment Study: biofeedback protocols and acquisition of temperature biofeedback skills. *Appl Psychophysiol Biofeedback*. 2001 Dec;26(4):251-78.
125. Minardi D, d'Anzeo G, Parri G, Polito M Jr, Piergallina M, El Asmar Z, Marchetti M, Muzzonigro G. The role of uroflowmetry biofeedback and biofeedback training of the pelvic floor muscles in the treatment of recurrent urinary tract infections in women with dysfunctional voiding: a randomized controlled prospective study. *Urology*. 2010 Jun;75(6):1299-304.
126. Moore D, Young CJ. A systematic review and meta-analysis of biofeedback therapy for dyssynergic defaecation in adults. *Tech Coloproctol*. 2020 Sep;24(9):909-918. doi: 10.1007/s10151-020-02230-9
127. Nagai Y, Goldstein LH, Fenwick PB, Trimble MR. Clinical efficacy of galvanic skin response biofeedback training in reducing seizures in adult epilepsy: a preliminary randomized controlled study. *Epilepsy Behav*. 2004 Apr;5(2):216-23.
128. Nakao M, Yano E, Nomura S, Kuboki T. Blood pressure-lowering effects of biofeedback treatment in hypertension: a meta-analysis of randomized controlled trials. *Hypertens Res*. 2003 Jan;26(1):37-46.

129. Narayanan SP, Bharucha AE. A Practical Guide to Biofeedback Therapy for Pelvic Floor Disorders. *Curr Gastroenterol Rep*. 2019 Apr 23;21(5):21.
130. Nascimento RP, Falsetta ML, Maurer T, Sarmiento ACA, Gonçalves AK. Efficacy of Physiotherapy for Treating Vulvodynia: A Systematic Review. *J Low Genit Tract Dis*. 2024 Jan 1;28(1):54-63.
131. National Center for Complementary and Alternative Medicine (NCCAM). Mind-Body medicine: an overview. Sept 24, 2024. Retrieved on September 4, 2025 from <http://nccam.nih.gov/health/providers/camterms.htm>
132. National Institute for Health and Clinical Excellence (NICE). Clinical guideline 61. Irritable bowel syndrome in adults. Diagnosis and management of irritable bowel syndrome in primary care. Feb 2008; updated Apr 2017. Retrieved on September 4, 2025 from <http://guidance.nice.org.uk/CG61>
133. National Institute for Health and Clinical Excellence (NICE). Clinical guideline 99. Constipation in children and young people: full guidance. May 26, 2010; updated 2017. Retrieved on September 4, 2025 from <https://www.nice.org.uk/guidance/cg99>
134. National Institute for Health and Clinical Excellence (NICE). Clinical guideline 217. Epilepsies in children, young people and adults. April 2022. Retrieved on September 4, 2025 from <https://www.nice.org.uk/guidance/ng217>
135. National Institute for Health and Clinical Excellence (NICE). Clinical guideline 49. Faecal incontinence in adults: management. Jun 2007. Retrieved on September 4, 2025 from <https://www.nice.org.uk/guidance/cg49>
136. National Institute for Health and Clinical Excellence (NICE). Clinical guideline 123. Urinary incontinence and pelvic organ prolapse in women: management. Jun 2019. Retrieved on September 4, 2025 from <https://www.nice.org.uk/guidance/ng123>
137. NCCN Clinical Practice Guidelines in Oncology®. ©2021 National Comprehensive Cancer Network, Inc. Adult Cancer Pain. Retrieved September 4, 2025 from <https://www.nccn.org/framework/>
138. Nebilet R, Mayer TG, Brede E, Gatchel RJ. Correcting abnormal flexion-relaxation in chronic lumbar pain: responsiveness to a new biofeedback training protocol. *Clin J Pain*. 2010 Jun;26(5):403-9.
139. Nelson LA. The role of biofeedback in stroke rehabilitation: past and future directions. *Top Stroke Rehabil*. 2007 Jul-Aug;14(4):59-66.
140. Nestoriuc Y, Martin A. Efficacy of biofeedback for migraine: a meta-analysis. *Pain*. 2007 Mar;128(1-2):111-27.
141. Nestoriuc Y, Rief W, Martin A. Meta-analysis of biofeedback for tension-type headache: Efficacy, specificity, and treatment moderators. *J Consult Clin Psychol*. 2008 Jun;76(3):379-96.
142. [No author]. Comparison of sustained-release nifedipine and temperature biofeedback for treatment of primary Raynaud phenomenon. Results from a randomized clinical trial with 1-year follow-up. *Arch Intern Med*. 2000 Apr 24;160(8):1101-8.
143. Norton C, Cody JD. Biofeedback and/or sphincter exercises for the treatment of faecal incontinence in adults. *Cochrane Database of Systematic Reviews* 2012, Issue 7. Art. No.: CD002111. DOI: 10.1002/14651858.CD002111.pub3
144. Norton C, Cody JD, Hosker G. Biofeedback and/or sphincter exercises for the treatment of faecal incontinence in adults. *Cochrane Database Syst Rev*. 2006 Jul 19;3:CD002111.

145. Norton C, Hosker G, Brazzelli M. Biofeedback and/or sphincter exercises for the treatment of faecal incontinence in adults. *The Cochrane Review*. In: *The Cochrane Library*, Issue 2, 2000. Update Jan 31, 2002. Chichester, UK: John Wiley & sons, Ltd.; 2002.
146. Norton C, Chelvanayagam S, Wilson-Barnett J, Redfern S, Kamm MA. Randomized controlled trial of biofeedback for fecal incontinence. *Gastroenterol*. 2003 Nov;125(5):1320-9.
147. Ostelo RW, van Tulder MW, Vlaeyen JW, Linton SJ, Morley SJ, Assendelft WJ. Behavioural treatment for chronic low-back pain. *The Cochrane Review*. In: *The Cochrane Library*, Issue 2, 2000. Update Oct 1, 2003. Chichester, UK: John Wiley & sons, Ltd.; 2005.
148. Patcharatrakul T, Rao SS. Update on the Pathophysiology and Management of Anorectal Disorders. *Gut Liver*. 2018 Jul; 12(4): 375–384
149. Patel K, Sutherland H, Henshaw J, Taylor JR, Brown CA, Casson AJ, Trujillo-Barreton NJ, Jones AKP, Sivan M. Effects of neurofeedback in the management of chronic pain: A systematic review and meta-analysis of clinical trials. *Eur J Pain*. 2020 Sep;24(8):1440-1457. doi: 10.1002/ejp.1612.
150. Patil AU, Lin C, Lee SH, et al. Review of EEG-based neurofeedback as a therapeutic intervention to treat depression. *Psychiatry Res Neuroimaging*. 2023;329:111591. doi:10.1016/j.pscychresns.2023.111591
151. Payne, CK. Chapter 63 – Conservative management of urinary incontinence: behavioral and pelvic floor therapy, urethral and pelvic devices. *Pelvic floor rehabilitation*. In; Wein AJ, Kavoussi LR, Novick AC, Partin AW, Peters CA, editors. *Wein: Campbell-Walsh Urology*, 9th ed. Orlando, FL. WB Sanders Company. 2007.
152. Peirce C1, Murphy C, Fitzpatrick M, Cassidy M, Daly L, O'Connell PR, O'Herlihy C. Randomised controlled trial comparing early home biofeedback physiotherapy with pelvic floor exercises for the treatment of third-degree tears (EBAPT Trial). *BJOG*. 2013 Sep;120(10):1240-7.
153. Pindi P, Houenou J, Piguet C, Favre P. Real-time fMRI neurofeedback as a new treatment for psychiatric disorders: A meta-analysis. *Prog Neuropsychopharmacol Biol Psychiatry*. 2022;119:110605. doi:10.1016/j.pnpbp.2022.110605
154. Pollock A, Baer G, Pomeroy V, Langhorne P. Physiotherapy treatment approaches for the recovery of postural control and lower limb function following stroke. *Cochrane Database Syst Rev*. 2007 Jan 24;(1):CD001920.
155. Pollock A, Baer G, Pomeroy V, Langhorne P. Physiotherapy treatment approaches for the recovery of postural control and lower limb function following stroke. *Cochrane Database Syst Rev*. 2003;(2):CD001920.
156. Porena M, Costantini E, Rociola W, Mearini E. Biofeedback successfully cures detrusor-sphincter dyssynergia in pediatric patients. *J Urol*. 2000 Jun;163(6):1927-31.
157. Pun MY, Leung PH, Chan TC, Pang C, Chan KH, Kannan P. The effectiveness of physiotherapy interventions on fecal incontinence and quality of life following colorectal surgery: a systematic review and meta-analysis of randomized controlled trials. *Support Care Cancer*. 2024 Jan 13;32(2):103.
158. Qi W, Zhou Y, Zhong M, et al. The effect of biofeedback treatment for children with non-neurogenic voiding dysfunction: A systematic review and meta-analysis [published online ahead of print, 2022 Feb 22]. *Neurourol Urodyn*. 2022;10.1002/nau.24886.
159. Rahmani E, Mahvelati A, Alizadeh A, et al. Is neurofeedback effective in children with ADHD? A systematic review and meta-analysis. *Neurocase*. 2022;28(1):84-95. doi:10.1080/13554794.2022.2027456

160. Ramaratnam S, Baker GA, Goldstein LH. Psychological treatments for epilepsy. *Cochrane Database Syst Rev*. 2008, Issue 3. Art. No.: CD002029. DOI: 10.1002/14651858.CD002029.pub3. Assessed as up-to-date Feb 15, 2011.
161. Rao SS, Benninga MA, Bharucha AE, Chiarioni G, Di Lorenzo C, Whitehead WE. ANMS-ESNM position paper and consensus guidelines on biofeedback therapy for anorectal disorders. *Neurogastroenterol Motil*. 2015 May;27(5):594-609.
162. Rao SS, Seaton K, Miller M, Brown K, Nygaard I, Stumbo P, Zimmerman B, Schulze K. Randomized controlled trial of biofeedback, sham feedback, and standard therapy for dyssynergic defecation. *Clin Gastroenterol Hepatol*. 2007 Mar;5(3):331-8.
163. Rao SS, Patcharatrakul T. Diagnosis and Treatment of Dyssynergic Defecation. *J Neurogastroenterol Motil*. 2016 Jul; 22(3): 423–435.
164. Rao SS, Bharucha AE, Chiarioni G, Felt-Bersma R, Knowles C, Malcolm A, Wald A. Functional Anorectal Disorders. *Gastroenterology*. 2016 Mar 25. pii: S0016-5085(16)00175-X.
165. Reiner R. Integrating a portable biofeedback device into clinical practice for patients with anxiety disorders: results of a pilot study. *Appl Psychophysiol Biofeedback*. 2008 Mar;33(1):55-61.
166. Reiter K, Andersen SB, Carlsson J. Neurofeedback Treatment and Posttraumatic Stress Disorder: Effectiveness of Neurofeedback on Posttraumatic Stress Disorder and the Optimal Choice of Protocol. *J Nerv Ment Dis*. 2016 Feb;204(2):69-77.
167. Remes-Troche JM, Coss-Adame E, García-Zermelo KR, Gómez-Escudero O, Amieva-Balmori M, Gómez-Castaños PC, Charúa-Guindic L, Icaza-Chávez ME, López-Colombo A, Morel-Cerda EC, Pérez Y López N, Rodríguez-Leal MC, Salgado-Nesme N, Sánchez-Avila MT, Valdovinos-García LR, Vergara-Fernández O, Villar-Chávez AS. The Mexican consensus on fecal incontinence. *Rev Gastroenterol Mex (Engl Ed)*. 2023 Oct-Dec;88(4):404-428.
168. Reneau M. Heart Rate Variability Biofeedback to Treat Fibromyalgia: An Integrative Literature Review. *Pain Manag Nurs*. 2020 Jun;21(3):225-232. doi: 10.1016/j.pmn.2019.08.001.
169. Renton T, Tibbles A, Topolovec-Vranic J. Neurofeedback as a form of cognitive rehabilitation therapy following stroke: A systematic review. *PLoS One*. 2017 May 16;12(5):e0177290.
170. Richards R, van den Noort JC, Dekker J, Harlaar J. Gait Retraining With Real-Time Biofeedback to Reduce Knee Adduction Moment: Systematic Review of Effects and Methods Used. *Arch Phys Med Rehabil*. 2017 Jan;98(1):137-150.
171. Sadeghi A, Akbarpour E, Majidrad F, et al. Dyssynergic Defecation: A Comprehensive Review on Diagnosis and Management. *Turk J Gastroenterol*. 2023;34(3):182-195. doi:10.5152/tjg.2023.22148
172. Saif MGM, Sushkova L. Clinical efficacy of neurofeedback protocols in treatment of Attention Deficit/Hyperactivity Disorder (ADHD): A systematic review. *Psychiatry Res Neuroimaging*. 2023;335:111723. doi:10.1016/j.pscychresns.2023.111723
173. Sam E, Cinislioglu AE, Yilmazel FK, Demirdogen SO, Yilmaz AH, Karabulut I. Is biofeedback-assisted pelvic floor muscle training superior to pelvic floor muscle training alone in the treatment of dysfunctional voiding in women? A prospective randomized study. *Int Braz J Urol*. 2022;48(3):501-511. Doi:10.1590/S1677-5538.IBJU.2021.0687
174. Shamliyan TA, Kane RL, Wyman J, Wilt TJ. Systematic review: randomized, controlled trials of nonsurgical treatments for urinary incontinence in women. *Ann Intern Med*. 2008 Mar 18;148(6):459-73. Epub 2008 Feb 11.

175. Shedden Mora MC<sup>1</sup>, Weber D, Neff A, Rief W. Biofeedback-based cognitive-behavioral treatment compared with occlusal splint for temporomandibular disorder: a randomized controlled trial. *Clin J Pain*. 2017 Aug;33(8):511-520.
176. Skardoorn GR, Khera AJ, Emmanuel AV, Burgell RE. Review article: dyssynergic defaecation and biofeedback therapy in the pathophysiology and management of functional constipation. *Aliment Pharmacol Ther*. 2017 Aug;46(4):410-423.
177. Soares-Silva L, de Amorim CS, Magno MB, Tavares-Silva C, Maia LC. Effects of different interventions on bruxism: an overview of systematic reviews. *Sleep Breath*. 2024;28(3):1465-1476. doi:10.1007/s11325-023-02961-7
178. Sokhadze TM, Cannon RL, Trudeau DL. EEG biofeedback as a treatment for substance use disorders: review, rating of efficacy, and recommendations for further research. *Appl Psychophysiol Biofeedback*. 2008 Mar;33(1):1-28.
179. Souto LR, De Oliveira Silva D, Pazzinatto MF, Siqueira MS, Moreira RFC, Serrão FV. Are adjunct treatments effective in improving pain and function when added to exercise therapy in people with patellofemoral pain? A systematic review with meta-analysis and appraisal of the quality of interventions. *Br J Sports Med*. 2024;58(14):792-804. Published 2024 Jul 1. doi:10.1136/bjsports-2024-108145
180. Spencer J, Wolf SL, Kesar TM. Biofeedback for Post-stroke Gait Retraining: A Review of Current Evidence and Future Research Directions in the Context of Emerging Technologies. *Front Neurol*. 2021;12:637199. Published 2021 Mar 30.
181. Stanton R, Ada L, Dean CM, Preston E. Biofeedback improves activities of the lower limb after stroke: a systematic review. *J Physiother*. 2011;57(3):145-55.
182. Stanton R, Ada L, Dean CM, Preston E. Biofeedback improves performance in lower limb activities more than usual therapy in people following stroke: a systematic review. *J Physiother*. 2017 Jan;63(1):11-16.
183. Steingrimsson S, Bilonic G, Ekelund AC, et al. Electroencephalography-based neurofeedback as treatment for post-traumatic stress disorder: A systematic review and meta-analysis. *Eur Psychiatry*. 2020;63(1):e7. Published 2020 Jan 31. doi:10.1192/j.eurpsy.2019.7
184. Sterman MB. Biofeedback in the treatment of epilepsy. *Cleve Clin J Med*. 2010 Jul;77 Suppl 3:S60-7.
185. Stockdale CK, Lawson HW. 2013 Vulvodynia Guideline update. *J Low Genit Tract Dis*. 2014 Apr;18(2):93-100.
186. Tabbers MM, DiLorenzo C, Berger MY, Faure C, Langendam MW, Nurko S, Staiano A, Vandenplas Y, Benninga MA; European Society for Pediatric Gastroenterology, Hepatology, and Nutrition; North American Society for Pediatric Gastroenterology. Evaluation and treatment of functional constipation in infants and children: evidence-based recommendations from ESPGHAN and NASPGHAN. *J Pediatr Gastroenterol Nutr*. 2014 Feb;58(2):258-74. Retrieved on September 4, 2025 from [https://www.naspghan.org/files/documents/pdfs/cme/jpgn/Evaluation\\_and\\_Treatment\\_of\\_Functional.24.pdf](https://www.naspghan.org/files/documents/pdfs/cme/jpgn/Evaluation_and_Treatment_of_Functional.24.pdf)
187. Tate JJ, Milner CE. Real-time kinematic, temporospatial, and kinetic biofeedback during gait retraining in patients: a systematic review. *Phys Ther*. 2010 Aug;90(8):1123-34.
188. Todhunter-Brown A, Hazelton C, Campbell P, Elders A, Hagen S, McClurg D. Conservative interventions for treating urinary incontinence in women: an Overview of Cochrane systematic reviews. *Cochrane Database Syst Rev*. 2022;9(9):CD012337. Published 2022 Sep 2. doi:10.1002/14651858.CD012337.pub2

189. Tiriyaki P, Çelik D, Bilsel K, Erşen A. Effectiveness of Exercises With Electromyographic Biofeedback in Conservative Treatment of Massive Rotator Cuff Tears: A Randomized Controlled Study. *Am J Phys Med Rehabil*. 2023;102(5):419-426. doi:10.1097/PHM.0000000000002111
190. Treadwell, J. R., Tsou, A. Y., Rouse, B., Ivlev, I., Fricke, J., Buse, D. C., Powers, S. W., Minen, M., Szperka, C. L., & Mull, N. K. (2025). Behavioral interventions for migraine prevention: A systematic review and meta-analysis. *Headache*, 65(4), 668–694. <https://doi.org/10.1111/head.14914>
191. Treatments for Fecal Incontinence. Content last reviewed March 2021. Effective Health Care Program, Agency for Healthcare Research and Quality, Rockville, MD. Retrieved on September 4, 2025 from <https://effectivehealthcare.ahrq.gov/products/fecal-incontinence>
192. U.S. Food and Drug Administration (FDA). Title 21—food and drugs. Biofeedback device. Apr 1, 2015. Retrieved on September 4, 2025 from <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfCFR/CFRSearch.cfm?FR=882.5050>
193. Vasudeva S, Claggett AL, Tietjen GE, McGrady AV. Biofeedback-assisted relaxation in migraine headache: relationship to cerebral blood flow velocity in the middle cerebral artery. *Headache*. 2003;43:245-50.
194. Vitton V, Damon H, Benezech A, Bouchard D, Brardjanian S, Brochard C, Coffin B, Fathallah N, Higuero T, Jouët P, Leroi AM, Luciano L, Meurette G, Piche T, Ropert A, Sabate JM, Siproudhis L; SNFCP CONSTI Study Group. Clinical practice guidelines from the French National Society of Coloproctology in treating chronic constipation. *Eur J Gastroenterol Hepatol*. 2018 Apr;30(4):357-363. doi: 10.1097/MEG.0000000000001080.
195. Vonthein R, Heimerl T, Schwandner T, Ziegler A. Electrical stimulation and biofeedback for the treatment of fecal incontinence: a systematic review. *Int J Colorectal Dis*. 2013 Nov;28(11):1567-77.
196. Wagner B, Steiner M, Huber DFX, Crevenna R. The effect of biofeedback interventions on pain, overall symptoms, quality of life and physiological parameters in patients with pelvic pain : A systematic review. *Wien Klin Wochenschr*. 2022;134(Suppl 1):11-48.
197. Wahbeh H, Elsas SM, Oken BS. Mind-body interventions: applications in neurology. *Neurology*. 2008 Jun 10;70(24):2321-8.
198. Wang LF1, Long H, Deng M, Xu H, Fang J, Fan Y, Bai D, Han XL. Biofeedback treatment for sleep bruxism: a systematic review. *Sleep Breath*. 2014 May;18(2):235-42.
199. Wang R, Zhang S, Zhang J, Tong Q, Ye X, Wang K, Li J. Electromyographic biofeedback therapy for improving limb function after stroke: A systematic review and meta-analysis. *PLoS One*. 2024 Jan 11;19(1):e0289572.
200. Wang X, Qiu J, Li D, et al. Pressure-Mediated Biofeedback With Pelvic Floor Muscle Training for Urinary Incontinence: A Randomized Clinical Trial. *JAMA Netw Open*. 2024;7(11):e2442925. Published 2024 Nov 4. doi:10.1001/jamanetworkopen.2024.42925
201. Wasielewski NJ, Parker TM, Kotsko KM. Evaluation of electromyographic biofeedback for the quadriceps femoris: a systematic review. *J Athl Train*. 2011;46(5):543-54.
202. Wattchow KA, McDonnell MN, Hillier SL. Rehabilitation Interventions for Upper Limb Function in the First Four Weeks Following Stroke: A Systematic Review and Meta-Analysis of the Evidence. *Arch Phys Med Rehabil*. 2018 Feb;99(2):367-382.
203. Weber W, Newmark S. Complementary and alternative medical therapies for attention-deficit/hyperactivity disorder and autism. *Pediatr Clin North Am*. 2007 Dec;54(6):983-1006; xii.



204. Wegh CAM, Baaleman DF, Tabbers MM, Smidt H, Benninga MA. Non-pharmacological Treatment for Children With Functional Constipation: A Systematic Review and Meta-analysis [published online ahead of print, 2021 Sep 15]. *J Pediatr.* 2021;S0022-3476(21)00883-0. doi:10.1016/j.jpeds.2021.09.010
205. Weinstein MM, Dunivan GC, Guaderrama NM, Richter HE. A Motion-based Device Urinary Incontinence Treatment: A Longitudinal Analysis at 18 and 24 Months. *Int Urogynecol J.* 2024;35(4):803-810. doi:10.1007/s00192-023-05721-z
206. Weise C, Heinecke K, Rief W. Biofeedback-based behavioral treatment for chronic tinnitus: results of a randomized controlled trial. *J Consult Clin Psychol.* 2008 Dec;76(6):1046-57.
207. Westwood SJ, Aggensteiner PM, Kaiser A, et al. Neurofeedback for Attention-Deficit/Hyperactivity Disorder: A Systematic Review and Meta-Analysis. *JAMA Psychiatry.* 2025;82(2):118-129. doi:10.1001/jamapsychiatry.2024.3702
208. Woodford H, Price C. EMG biofeedback for the recovery of motor function after stroke. *Cochrane Database Syst Rev.* 2007 Apr 18;(2):CD004585.
209. Wu X, Zheng X, Yi X, Lai P, Lan Y. Electromyographic Biofeedback for Stress Urinary Incontinence or Pelvic Floor Dysfunction in Women: A Systematic Review and Meta-Analysis. *Adv Ther.* 2021;38(8):4163-4177.
210. Xia Z, Yang PY, Chen SL, Zhou HY, Yan C. Uncovering the power of neurofeedback: a meta-analysis of its effectiveness in treating major depressive disorders. *Cereb Cortex.* 2024;34(6):bhae252. doi:10.1093/cercor/bhae252
211. Xie YJ, Wang S, Gong QJ, et al. Effects of electromyography biofeedback for patients after knee surgery: A systematic review and meta-analysis. *J Biomech.* 2021;120:110386.
212. Yagci S, Kibar Y, Akay O, Kilic S, Erdemir F, Gok F, Dayanc M. The effect of biofeedback treatment on voiding and urodynamic parameters in children with voiding dysfunction. *J Urol.* 2005 Nov;174(5):1994-7; discussion 1997-8. Yilmaz OO, Senocak O, Sahin E, Baydar M, Gulbahar S, Bircan C, Alper S. Efficacy of EMG-biofeedback in knee osteoarthritis. *Rheumatol Int.* 2010 May;30(7):887-92.
213. Yang JM, Ye H, Long Y, et al. Effect of pelvic floor muscle training on urinary incontinence after radical prostatectomy: An umbrella review of meta-analysis and systematic review. *Clin Rehabil.* 2023;37(4):494-515. doi:10.1177/02692155221136046
214. Yao L, Sadeghirad B, Li M, Li J, Wang Q, Crandon HN, Martin G, Morgan R, Florez ID, Hunskaar BS, Wells J, Moradi S, Zhu Y, Ahmed MM, Gao Y, Cao L, Yang K, Tian J, Li J, Zhong L, Couban RJ, Guyatt GH, Agoritsas T, Busse JW. Management of chronic pain secondary to temporomandibular disorders: a systematic review and network meta-analysis of randomised trials. *BMJ.* 2023 Dec 15;383:e076226.
215. Yucha CB, Clark L, Smith M, Uris P, LaFleur B, Duval S. The effect of biofeedback in hypertension. *Applied Nursing Research.* 2001;14(1):29-35.
216. Zhang Y, Hou S, Qi Z, Wu S, Zhu K, Wang W. Non-pharmacological and nonsurgical interventions in male urinary incontinence: A scoping review. *J Clin Nurs.* 2023;32(17-18):6196-6211. doi:10.1111/jocn.16749
217. Zijlstra A, Mancini M, Chiari L, Zijlstra W. biofeedback for training balance and mobility tasks in older populations: a systematic review. *J Neuroeng Rehabil.* 2010 Dec 9:58.

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