

Updates on Brain-focused Interventions for Treating ADHD and Executive Function Challenges

This supplemental handout provides more information about what we know about brain-focused interventions and ADHD in relation to executive function challenges. The interventions reviewed include exercise, mindfulness meditation, neurofeedback, brain training, dietary treatments and brain stimulation.

Exercise

1. What types of exercise programs have been studied in children and teens with ADHD ?
 - Both acute and chronic exercise have been studied as an intervention for ADHD symptoms
 - Acute exercise means a single 15-30 minute bout of exercise before an attention-demanding task, for example, running on a treadmill before studying for a test
 - Chronic exercise means an ongoing program of exercise, for example, running on a treadmill for 20 minutes 3 times per week for 10 weeks
 - Two types of chronic exercise have been studied- aerobic exercise, such as running, and “strategic” exercise that involves learning specific skills, such as playing soccer or tennis
2. What is the evidence for effectiveness in ADHD?
 - Similar to controls, exercise improves attention and cognitive skills in children with ADHD; positive effects are small to medium in degree
 - ADHD symptom improvements are found on rating scales and tests of attention
 - Generally, improvement on tests is more robust than improvement on behavioral measures of ADHD (Halperin, et al., 2014)
 - Improvements in attention are more common than improvements in hyperactivity/impulsivity
 - Exercise has been shown to change QEEG measures of brainwaves toward normal levels in children with ADHD, though this does not guarantee that changes will be seen in behavior (Kirkland & Holton, 2019).
3. What is the evidence for effectiveness for executive functions (EFs)?
 - Both acute and chronic exercise have been shown to improve working memory, inhibitory control, and cognitive flexibility in typically-developing children and adolescents (Chang, et al., 2012; Christiansen et al., 2019; Liu, et al., 2020). Chronic exercise has more consistent effects on EFs and may also improve academic performance (de Greeff, et al., 2018)
 - Similar findings have been found in children with ADHD- improvements are seen in attention, working memory, inhibition, cognitive flexibility, and processing speed. Chronic exercise has more substantial effects than acute exercise, and can lead to positive effects on academics (Christiansen et al., 2019)
 - Not all cognitive skills are helped, and not all to a similar degree across all studies. There are differences found across studies in which aspects of EF improve, or improve the most.
 - Exercise is one of the few treatments that has been shown to have a positive effect on cognitive flexibility (Ludyga, et al., 2020).

- It appears that “effort” is required for positive effects, not simply movement (Christiansen, et al., 2019) although increased “intensity” does not always provide more benefit (Vyaniauske, et al., 2020).
4. What is the evidence for persistence of effects ?
 - There is very limited study of the persistence of positive effects after stopping the exercise program, but some information suggests persistence after 2 weeks post-treatment.
 - There is also no direct study of whether benefits increase further as chronic exercise programs continue past 12 weeks.
 5. Other effects of exercise
 - Exercise may improve physical fitness, motor skill, emotional regulation, processing speed, reaction time, sleep, anxiety, depression symptoms, social functioning and self-esteem in children with ADHD (See reviews below, also Silva, et al., 2020)
 - Anxiety is one of the more commonly-reported non-ADHD improvements.
 6. What level of exercise is needed to see an effect ?
 - For acute exercise, 20-30 minutes at 65-80% of maximal heart rate (moderate intensity)
 - For chronic exercise, at least 45 minutes 3 times per week at moderate intensity for 6 to 12 weeks provides the best benefit for programs of this length of time (Maximal heart rate is 220-age in years) (Christiansen, et al., 2019; Khodaverdi, et al., 2022; Wang, et al., 2023)
 - A review of studies that specifically measured inhibition after chronic exercise found that 60 minutes of skill-based exercise twice weekly for several weeks showed more improvement than shorter durations (Wang et al., 2023)
 7. Things to consider about this treatment
 - Overall, exercise has the most evidence for effectiveness for improving EFs in children with ADHD of the brain-focused treatments other than medication.
 - It may also improve other co-existing symptoms such as anxiety or low self-esteem that can be problematic for children with ADHD.
 - It must be kept in mind, however, that it is practically impossible to do a “blinded” study of exercise.
 - The degree of improvement in attention and EFs is less in the treated group when the control group receives a different treatment rather than no treatment.
 - For acute exercise, less than 20 minutes is unlikely to have a positive effect and more than 30 minutes does not add benefit
 - Chronic exercise tends to be more beneficial than individual bouts of acute exercise
 - As with brain training, improvements are more likely when the exercise program is “adaptive” meaning that as skill/ endurance increases, so should the level of demand.
 - See the following reviews (Cerrillo-Urbina, et al., 2015; Christiansen, et al., 2019; Halperin, et al., 2014; Jeyanthi, et al., 2019; Sun, et al., 2022; Tan, et al., 2016; Villa-González, et al., 2020; Vysniauske, et al., 2020; Wang, et al., 2023)

Neurofeedback

1. What is neurofeedback ?

- It is a type of biofeedback combined with behavioral reinforcement in which an individual learns to control aspects of brain electrical activity that are altered in ADHD by earning rewards for successful attempts. It is usually practiced in the form of a computer game.
 - It has been in existence as a treatment since the 1970s, but in the last decade, more careful research has been done to better understand its effects.
 - Decades of research indicates that several aspects of electrical activity differ in the brains of individuals with ADHD in comparison to controls. There is a solid theoretical basis for neurofeedback as a treatment, but study results have been mixed.
2. What are the different types of neurofeedback ?
- EEG frequency band training- Four types of electrical brain waves are measured on a quantitative EEG (electroencephalogram, QEEG). Alpha waves are produced in the brain during quiet but alert states; beta waves are produced during more focused alertness, but a higher frequency subtype of beta waves are produced during hyper-alertness or overstimulation; theta waves are produced when the brain is drowsy, and delta waves are produced during sleep. Individuals with ADHD tend to have lower levels of alpha and focused beta waves and higher levels of hyper-beta and theta waves. Neurofeedback protocols typically aim to decrease theta and increase the focused beta waves, or to decrease the “over-stimulated” beta waves.
 - Training slow cortical potentials (SCP)- SCP are the brain’s later electrical responses to a stimulus (not the initial recognition of the stimulus), and as such, may be related to “top down” cognitive processing. In this type of neurofeedback, an individual is trained to regulate the threshold for generating this response.
 - A more recent type of neurofeedback uses real-time functional magnetic resonance imaging (fMRI) rather than QEEG. In this method, the subject is trained to increase activity in a specific part of the brain using a similar computer game and reward system as is used in EEG neurofeedback. Areas targeted for increasing activation are those involved in self-regulation. One recent study of this procedure in children with ADHD targeted the right inferior frontal cortex, and did not find differences between the treated and control group on the ADHD Rating Scale after 4 1-hour sessions or 6 months later (Lam, et al., 2022). However, complex brain functions happen in networks, not individual areas. We don’t know how “artificially” activating one part of a network affects the others, and there have not yet been studies that compare the two neurofeedback methods in a head-to-head study. We also do not know what “doses” are needed to potentially translate fMRI changes into behavior changes. This form of neurofeedback is currently a research tool, rather than an available treatment (Pindi, et al., 2022; Taschereau-Dumouchel, et al., 2022).
3. How is neurofeedback conducted ? (reviewed in Zhang, et al., 2023)
- A baseline QEEG is obtained to get measurements before treatment and to identify the main differences from controls for that particular individual.
 - Some practitioners (who are typically psychologists) individualize the training protocol based on that individual’s differences while others are trained to administer a single protocol to all subjects.

- Between 20-60 weekly or twice-weekly sessions are required. At various points in the process, a repeat QEEG is obtained to monitor progress.
 - There is some evidence for a higher rate of clinical improvement when the training is individualized (Arns, et al., 2020; Krepel, et al., 2020). Between 50-80% of children can be successfully trained to modify their brain waves in the desired direction (Gevensleben et al., 2009; Kropotov et al., 2005; Okumura et al., 2019) however, most studies do not take this into account which may be one factor causing variability in results (Kuznetsova, et al., 2023)
4. What is the evidence for effectiveness in ADHD?
- Most, but not all, studies find small to medium improvements in ADHD symptoms, typically measured by rating scales (Holtman, et al., 2014; Moreno-Garcia, et al., 2023).
 - When studies have a control group that does a similar, but not exactly the same activity (also called a “sham” treatment), and when the person measuring the change in brain waves does not know if the subject they are measuring had neurofeedback or the sham treatment (when the observer is “blind”), smaller, or even no differences, are found.
 - There is a great deal of variability in the study outcomes, from substantial rates of success to no difference after neurofeedback treatment at all. The types of control groups and the lack of control for how many of the participants were successful in changing their brain waves are likely two of the factors that contribute to this variability (Kuznetsova et al., 2023).
 - Effects of neurofeedback are typically less than the effects of medication (Holtman, et al., 2014; Moreno-Garcia, et al., 2023; Razoki, 2018; Yan et al., 2019)
5. What is the evidence for effectiveness for executive functions (EFs)?
- The effectiveness for EFs is similar to ADHD- small but positive and variable across studies.
 - When rating scales were used to measure EF, parents were often not blinded which may have increased positive results.
 - Several studies showed positive effects on continuous performance tests which measure behavioral inhibition in addition to attention and impulsivity.
 - A few studies show improvements in working memory, academic performance (Enriquez-Geppert, et al., 2019; Moreno-Garcia et al., 2023)
 - There may be some benefit to school-related daily life EFs such as organization and planning when neurofeedback is done in the school setting (Krell, et al., 2023).
6. What is the evidence for persistence of effects ?
- QEEG neurofeedback is one of the few treatments that appears to show continued improvement (Arns, et al., 2020) or persistence of improvement for up to 6 months post-treatment (Arns, et al., 2020; Gevensleben, et al., 2010; Moreno-Garcia, et al., 2022; Van Doren, et al., 2019)
 - A minority of subjects no longer met criteria for ADHD (Arns, et al., 2020)
 - Some subjects were able to take a decreased dose of medication (Razoki, 2018)
7. What to keep in mind if considering this treatment

- Evidence for effectiveness is controversial, even after many years of study
- Neurofeedback is not typically effective enough to be a stand-alone treatment, but may be a useful addition to medication, or for those who do not tolerate medication
- The protocol should be individualized to the child's electrical activity differences
- Ask how many sessions will be required to know whether or not the child is successful at learning the protocol
- Ask how clinical improvement will be measured, and whether the outcomes that will be measured are the most important ones for this child.
- Ask how many sessions it is expected to take to determine whether or not positive changes are occurring
- It is not likely to be covered by insurance; consider commitment of time and cost

Brain Training

1. What is brain training and what are the different types of brain training programs?
 - Brain training is also called cognitive training
 - It is a program of mental exercises (“games”) usually done on a computer, for practicing underlying cognitive skills, including core EFs. (See Zhang, et al., 2023)
 - A baseline (before treatment) test of each type of skill in the program is taken. The typical pattern of treatment (in research) is practice several times per week for 20-40 minutes each, for up to 12 weeks. The same series of tests are given after treatment to look for improvement.
 - There are increasing levels of difficulty for each skill built into the program; as success is achieved at a given level, the individual moves to the next harder level. This is important for achieving better scores on the post-treatment assessment compared with the pre-treatment assessment.
 - The most common skill practiced is working memory (holding information in mind while completing a task), however, the “executive” form of working memory includes updating incoming information *while* holding previous information in mind, and not all programs include this “executive” aspect of memory. Some experts would call simply remembering information during a task short-term memory rather than working memory (Kofler, et al., 2018).
 - Often, when memory is targeted by these programs, both verbal and visual memory “games” are included
 - Other skills practiced in some brain training programs include cognitive flexibility and inhibition (core EFs), as well as verbal and visual processing speed and accuracy
 - Rewards may need to be provided in order to get children to practice, but also to reinforce progress.
2. What is the evidence for effectiveness in ADHD?
 - Even though brain training has been studied since the early 2000s, results from different studies continue to be inconsistent.
 - Generally, parent ADHD rating scales show greater effects than teacher's, and in studies with better “blinding” of raters, positive effects tend to be much smaller or absent.
 - Small effects may be seen on measures of inattention, but hyperactivity-impulsivity are less likely to improve (Westwood, et al., 2023)
 - Neuropsychological tests are more likely to show improvement with treatment, but often the tests given at baseline and after treatment to measure effects are very similar

to the exercise that was practiced. These are called “near-transfer” effects, meaning that the effects of practice are evident in other activities that are very similar.

- Near-transfer effects have been found for attention, working memory, and response inhibition.
 - Test results for EF may not correlate with ADHD symptom improvement (Lee, et al., 2022)
3. What is the evidence for effectiveness for executive functions?
- Parent ratings of executive function and laboratory tests of working memory have shown improvement in some studies, but the same limitations about blinding and near-transfer effects described for ADHD outcomes apply to EF outcomes as well.
 - One (unblinded) study specifically evaluated the effects of brain training targeting working memory, inhibition, and cognitive flexibility, delivered in a group setting, on peer difficulties in children with ADHD. The control group received direct social skills intervention. The brain training intervention resulted in better results after treatment and more lasting improvement 3 months later, though both interventions improved peer difficulties in the short-term. The improvement with brain training appeared to be due primarily to improvement in ADHD symptoms and self-control (Lan, et al., 2018).
 - Cognitive flexibility is commonly less likely to improve compared to inhibition or working memory with any of the available ADHD treatments. In a recent study, training either inhibition or working memory skills in elementary-aged children, researchers found that training inhibitory skills was more effective than training working memory skills for improving cognitive flexibility (Irwin Harper, et al., 2023).
 - In another recent study, the same researchers trained working memory with more robust executive demands and found far-transfer effects on children’s organizational skills (Chan, et al., 2023).
4. What is the evidence for persistence of effects ?
- There is limited evidence (a small number of studies) that verbal working memory, when improved in the short-term, may persist (Chan, et al., 2023).
 - There is limited evidence that improvements in reading and reading comprehension may persist (Westwood, et al., 2023).
5. What to keep in mind if considering this treatment
- Evidence for effectiveness in high-quality studies is limited.
 - Some studies training working memory may be training short-term memory that does not include an executive (updating working memory) component (Kofler, et al., 2018).
 - We do not yet know if brain training can be an enhancement to other treatments.
 - We do not yet know if a particular subtype of ADHD or neuropsychological profile predicts a better or worse response to this type of treatment (Sonuga-Barke, et al., 2014).
 - Most studies do not show daily life executive improvements (far-transfer effects related to EF).
 - Brain training can be done at home, in the clinic, or in school settings
 - It is not likely to be covered by insurance; consider commitment of time and cost
 - See the following reviews (Caponnetto, et al., 2021; Cortese, et al., 2015; Katz, et al., 2018; Simons, et al., 2016; Sonuga-Barke, et al., 2014; Sun, et al., 2022; Westwood, et al., 2023).

Mindfulness Meditation

1. What is mindfulness meditation?
 - Mindfulness meditation is the practice of bring one’s attention to the experience of the present moment with an open, non-judgemental attitude (Kabat-Zinn, 2003).
 - Because it involves practicing the control of attention, it has the potential to lead to improved executive attention.
 - Long-term mindfulness meditation leads to changes in parts of the brain and body physiology that are consistent with increased cognitive control.
 - It is difficult for children to report when they are or are not meditating successfully; performing accompanying motor rituals, such as yoga, is thought to help children meditate more effectively.
 - Because of this, most studies have been done in adults and adolescents, and some of the reviews combine studies involving adults and children, and some combined meditation with yoga or other practices.
2. What is the evidence for effectiveness in ADHD?
 - Most studies (though not all) in adults and adolescents do find some improvements in ADHD symptoms (Caircross & Miller, 2020; Lo, et al., 2020; Oliva, et al., 2021; Poissant, et al., 2019; Xue, et al., 2019)
 - These gains are less compared with controls when the control group has a different treatment rather than no treatment (Xue, et al., 2019)
 - The newest review of studies in children, considering only randomized controlled trials, finds significant improvement in ADHD symptoms (Lee, et al., 2022)
 - Group mindfulness practice in the school setting has been shown to help attention to academics (Pinto, et al., 2023).
 - When attention improves with mindfulness training, so do QEEG measures that are consistent with increased attention at the brain electrical level (Sibalis, et al., 2019).
3. What is the evidence for effectiveness for executive functions?
 - The trait of mindfulness is associated with the core EFs in typically-developing children, adolescents, and adults (Geronimi, et al., 2020)
 - A subgroup of studies find positive effects on EF tests of working memory and inhibition compared with controls; positive treatment effects c/w those in the control group tend to be greater when the control group has no intervention, and are minimal to absent when the control group has another intervention (Lassander, et al., 2020; Zelazo, et al., 2018)
 - A small number of studies find improvements in EF based on teacher rating scales (Chimiklis, et al., 2018)
 - Group mindfulness practice in school setting has been shown to improve parent and/or teacher EF ratings (Flook, et al., 2010; Janz, et al., 2019) and tests (Janz, et al., 2019).
 - Mindfulness training did not add additional benefit in EF to intensive behavioral treatment in the Summer Treatment Program (Ramos, et al., 2022)
 - Daily life EFs have not been adequately studied
4. What is the evidence for persistence of effects ?

- One trial of mindfulness training in children showed improvements in ADHD and EF symptoms by parent and teacher ratings right after treatment, but hyperactivity-impulsivity remained improved after 6 months (Siebelink, et al., 2022).
 - Another trial in children and their parents showed improvements in parent reported children’s attention, EF tests, learning, aggression, and peer relations 6 months after treatment even though these improvements were not present right after treatment (Valero, et al., 2022).
 - A trial in children with cerebral palsy and their parents also showed declining effects on attention at 6 mos, but increased effects on EF and parent wellbeing (Mak, et al., 2020).
 - We don’t know whether or not the children in these trials continued to practice mindfulness.
5. Other effects of meditation:
- The most robust effects of meditation are in mindfulness itself, stress, internalizing symptoms (anxiety/ depression), and social-emotional characteristics (Dunning, et al., 2029)
 - Several trials of mindfulness also include parents which is likely important for their support of their child practicing at home. These trials show support for improvements in parent mindfulness, stress levels, and parent-child relationships by parent report (Chimiklis, et al., 2018; Lee, et al., 2022; Lo, et al., 2020; Siebelink, et al., 2022; Valero, et al., 2022).
 - Group mindfulness practice in the school setting has been shown to help emotional coping, self-regulation, stress, mood, and social relationships (Meiklejohn, et al., 2012; Pinto, et al., 2023).
6. What to keep in mind if considering this treatment
- The quality of studies in this field, especially pre-2020, is weak in terms of randomization, blinding, and adequate controls. This can falsely increase positive results.
 - Much of the available data is in young adults (college age) and adults.
 - This is unlikely a stand-alone treatment for ADHD, but is promising as an added treatment, especially for hyperactivity, parenting stress, self-regulation, and social-emotional symptoms.
 - See the following reviews: (Cairncross & Miller, 2020; Chimiklis, et al., 2018; Dunning, et al., 2019; Evans, et al., 2018; Lee, et al., 2022; Oliva, et al., 2021).

Nutrition and Diet Modifications

1. What types of nutritional/ diet interventions have been studied for ADHD?
 - Two broad types of nutrition/diet modifications have been studied for ADHD- nutritional supplements and elimination diets
 - Single nutrients and multi-nutrient supplements have been studied
 - Two types of elimination diets have been studied- the elimination of artificial colors, and the elimination of commonly allergenic foods (in the absence of a clear allergic reaction)
2. What is the evidence for effectiveness in ADHD?

- First, adequate nutrition is critical for brain development at all stages.
- Several studies that suggest that the quality of the maternal diet, and the diets of young children can influence the risk of ADHD (and mental health disorders) in adolescence. These are association studies, meaning that these 2 factors are related, but it doesn't prove that one causes the other. It is likely one contributing factor, however (Galera, et al., 2018; Howard, et al., 2011; Jack et al., 2013).
- Single nutrients that have shown some benefit for ADHD include iron, magnesium, zinc, but only when the individual is deficient (reviewed in Glanzman & Sell, 2019)
- Multi-nutrient supplements have shown more consistent positive effects on ADHD, aggression and emotional regulation (Rucklidge, et al., 2018).
- Polyunsaturated fatty acids (PUFA) have been studied extensively for ADHD and other learning and mental health conditions with controversial results, though across studies, a few positive results have been found (Gillies, et al., 2023; Pelsser, et al., 2017; Russell & Arnold, 2023).
- Most studies have included only the omega-3 type of PUFA, however early studies showed better results when a small amount of the anti-inflammatory omega-6 (GLA) was added to the supplement regimen. This has recently been confirmed (D'Helft, et al., 2022), and future studies with this regimen may show better results.
- Testing for deficiencies in essential fatty acids in children with ADHD is not routinely available/ covered by insurance for clinical purposes.
- While PUFA supplementation may be minimally helpful for ADHD, it appears to be most relevant to try for children with hyperactive-impulsive and oppositional symptoms, emotional dysregulation, and poor response to stimulants
- Allergist Ben Feingold first reported in the 1960s that eliminating artificial colors, artificial flavors, certain preservatives, and foods that contain high levels of naturally-occurring salicylates (aspirin-like compounds) could improve the behavior, learning, and mood of "hyperactive" children. It also was reported to improve physical symptoms such as allergy, ear infections, headaches, and sleep problems.
- The Feingold Diet was an expanded version of an established medical observation that a small number of individuals develop allergic symptoms and nasal polyps in response to the yellow dye, tartrazine and aspirin. This "expanded" version was tried in order to treat an adult patient with severe hives that were unresponsive to current treatments. It did, and she also reported improved focus, mood, and calmness which prompted him to try it in "hyperactive" children in his practice (personal communication).
- There is no study of the Feingold diet as Feingold defined it; rather there have been many studies of the elimination of artificial colors only. These show overall small positive effects, but several studies suggest a strong response in a subgroup of individuals (Goyette, et al., 1978; Kaplan, et al., 1989; Rowe & Rowe, 1994; Schmidt, et al., 1997; Swanson & Kinsbourne, 1980)
- Frequency of positive results has also likely been hampered by using only core ADHD symptoms for assessment of results, when some studies suggest that emotional regulation, sleep, and mood may be important effects. (Kaplan, et al., 1989; Rowe & Rowe, 1994).

- Similar effects of reduced ADHD symptoms and moodiness are seen in children without ADHD when artificial colors/ preservative are removed (Bateman, et al., 2004; McCann et al., 2007).
 - Exposure to artificial colors has been shown to affect brainwaves on QEEG (Kirkland, et al., 2020).
 - The elimination of commonly allergenic foods (the “few foods” diet, or “oligoantigenic” diet) has also shown benefit for ADHD although there are more concerns about blinding in these studies (Boris & Mandel, 1994; Carter, et al., 1993; Egger, et al., Pelsser, et al., 2011; Schmidt, et al., 1997)
 - All children who reacted to foods reacted to more than one and also reacted to artificial colors (Egger, et al., 1985).
 - When considering the elimination of both artificial colors and reactive foods, up to 33% of children with ADHD may respond to this intervention (Nigg, et al., 2012)
 - fMRI (Hontelez, et al., 2021) and brain electrical activity (Uhlir, et al., 1997) are altered by reactions to foods
3. What is the evidence for effectiveness for EFs?
 - There is very limited information about the effects of supplements and elimination diet strategies on EF.
 - The few studies of PUFA supplementation and neuropsychological tests of attention, working memory and cognitive switching show contradictory results.
 - A few studies of dietary elimination identify mood/ irritability and sleep improvements that may reflect emotional regulation
 4. Other nutritional/ diet effects:
 - Multi-nutrient supplementation can improve stress tolerance
 - Elimination of artificial colors can additives from school food can improve academic test scores (Schoenthaler, et al., 1986)
 - Elimination of artificial colors can improve sleep (Kaplan, et al., 1989)
 5. What do we know about long-term diet modification ?
 - There is no information about whether symptom improvement persists after stopping treatment after a certain length of supplementation or elimination.
 - Elimination diets are often reported to be nutritionally deficient. This is not necessarily the case, but may be if a child is a highly selective eater, which decreases the chance that nutritionally-equivalent substitutes will be accepted.
 - The oligoantigenic diet was not meant to be a long-term treatment, but rather a few-week “test” for food-triggered symptoms. It is anticipated that foods are added back one at a time, and that not all commonly allergenic foods will need to be eliminated long-term.
 - Consultation with a nutritionally-knowledgeable professional is warranted if a variety of foods from each of the food groups are not regularly consumed.
 - Minerals (iron, zinc, magnesium, calcium), PUFAs, and fat-soluble vitamins (A, E, D, K) are not easily eliminated from the body, and can accumulate and cause significant side effects. Supplements should be monitored under the care of a knowledgeable professional.

6. See the following reviews: Glanzman & Sell, 2019; Nigg, et al, 2012; Pelsser, et al., 2017; Russell & Arnold, 2023; Stevens, et al., 2011 and www.feingold.org

Non-invasive brain stimulation

1. Three types of brain stimulation are currently under study for improving ADHD as well as other behavioral health conditions in adults and children
 - Transcranial magnetic stimulation- delivers a magnetic pulse to areas of the brain involved in the condition under treatment from an external device. Most commonly used for depression that is not responsive to more standard treatments. It is FDA- approved for treating depression and obsessive compulsive disorder.
 - Transcranial direct current stimulation- electrical currents are used to stimulate areas of the brain involved in the condition under treatment. Used in depression, chronic pain, certain neurologic conditions, but not FDA-approved at this time
 - Trigeminal nerve stimulation- Less frequently studied, but FDA-approved.
2. All of these have been studied with initial positive and no significant negative results for children and adolescents with ADHD. At this time there are too few studies to draw conclusions, but these are promising treatments to follow going forward. As a relatively newer area of treatment, it is notable that many, rather than few of these studies include measures of executive function, highlighting the growing recognition of the importance of EFs for outcomes in ADHD among researchers.
3. See the following reviews: Enriqz-Geppert, et al., 2013; Lipka, et al., 2021; Memon, 2021; Salehinejad, et al., 2022; Santos, et al., 2021; Westwood, et al., 2020.

Selected References

Exercise

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