Children's Hospital of Philadelphia®

Updates on Brain-focused Interventions for Treating ADHD and Social Functioning Challenges

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

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 improvement in social functioning?
    - There are no available studies that specifically target social functioning as an outcome of exercise interventions.
    - There are several studies, of variable quality, that include either a specific social rating scale, or the social subscale from a broader rating that measures social impairment (reviewed in Seiffer, et al., 2021; also, Hoza, et al., 2015; Lufi & Parish-Plass, 2011;Smith, et al., 2013; Verret, et al., 2012).
    - Altogether, these studies suggest a variable effect of different exercise programs on social functioning, with an overall small improvement in problematic social behavior or improved peer interactions. However, some of the studies show no effect.
    - Studies with an active control group (ie Hoza, et al., 2015, art program; Jensen & Kenny, 2004, cooperative games) tend to show less difference between the intervention and control group after treatment.
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)
    - 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.

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; sometimes 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 effectiveness for social functioning?
    - Studies have not targeted effects on social function, but some studies include broad rating scales as outcome measures that include a subscale for social problems/ social functioning.
    - Typically, decreased in social problems were reported (Evans et al., 2018; Valero, et al., 2022)

- Social function may be impacted indirectly by decreases in negative behavior (Dunning, et al., 2019)
- Several studies find preliminary evidence for improved emotional regulation and social skills (Flook, et al., 2015; Tang, et al., 2014)
- Group mindfulness practice in the school setting has been shown to help emotional coping, self-regulation, stress, mood, and social relationships (Pinto, et al., 2023).
- When parents participate, there are improvements in parent emotional regulation and parent-child relationships (Siebelink, et al., 2021)

5. 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.
6. 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).
7. 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 (Uhlig, et al., 1997) are altered by reactions to foods

3. What is the evidence for effectiveness for social functioning ?
    - A few studies of dietary elimination identify mood/ irritability and sleep improvements that may reflect emotional regulation, which may secondarily improve social functioning, but there are no direct assessments of social functioning in these studies.
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

Additional brain-focused treatments (neurofeedback, brain training and neural stimulation) are reviewed in the corresponding pdf in the Executive Function sections. They are not reviewed here because there is insufficient information related to social functioning.

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Exercise

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<u>Mindfulness Meditation</u>

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