Computerized Training for Children with ADHD

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Summary and Conclusions

SBU's appraisal of the evidence

Attention Deficit Hyperactivity Disorder (ADHD) is the most common neuropsychiatric diagnosis in children and adolescents. ADHD is characterized by inattention, impulsiveness and hyperactivity to the extent that it affects the child's school results and relationships with friends and family.

Computerized training of working memory and neurofeedback are two methods aimed at increasing the child's capabilities to manage their problems.

- The scientific evidence is insufficient to determine whether computerized training of working memory or neurofeedback reduces symptoms of ADHD in children of school age.
- The scientific evidence is insufficient to determine whether computerized training of working memory and neurofeedback are associated with any risks.
- It is essential that children with ADHD have access to support services that are safe and effective. Controlled trials should be conducted to clarify the benefits and risks of computerized training of working memory and neurofeedback in the short and long term.

Target group and technologies

The target group for computerized training of working memory and neurofeedback are children with ADHD who are found to be in need of supportive interventions. In Sweden this group includes 30 000 to 40 000 children.

The diagnosis of ADHD is defined as a specific set of behavioral deviations/symptoms, including inattention, hyperactivity, and impulsiveness. Children with ADHD are in a long term perspective at greater risk for psychiatric disorders, substance abuse, and criminality when they reach adulthood. Adults with ADHD often have problems with relationships and working life.

Availability of effective methods to support children diagnosed with ADHD is limited. The established interventions include educational and psychosocial support for parents, preschools and schools, and pharmaceuticals. Since ADHD affects the child's life in many ways, multimodal interventions may be required.

This assessment addresses two nonpharmacological methods aimed to help children to improve attentiveness and control impulsiveness. Both methods directly target the child. They have been tested as single interventions and in combination with other interventions. The methods are based on two different theories on the causes of functional disturbances in ADHD.

Computerized training of working memory is based on the theory that an impaired working memory is one of the underlying problems in children with ADHD. The capacity of the working memory determines the ability to retain and process information and impressions during a short period. It is important for understanding instructions as well as for planning, reading, and mathematics. Working memory is also important in controlling behavior.

Two computerized programs for training of working memory are available in Sweden. Both programs are designed as computer games. As the child completes the exercises, the degree of difficulty increases, which aims to stretch the capacity of the working memory.

Neurofeedback is based on the theory that children with ADHD in some respects have slower activity in the brain, which can be registered via electroencephalography (EEG). The aim of neurofeedback is to train the children to concentrate and control their impulses. Educational computer programs are used in this context as well. The EEG pattern controls the content, and when it is normalized the child receives praise or points. The child should learn how a normal EEG pattern "feels".

Primary questions and limitations

- In the short and long term, how does computerized training of working memory and neurofeedback affect symptoms and functional capacity in children with ADHD?
- Are there any complications or adverse effects?
- Do any ethical or social aspects affect the use of the methods?
- What do the methods cost? Are they cost-effective?

The studies included in the review should meet the following criteria:

Study type: Randomized trials to determine effects. All study designs to determine risks, adverse effects, and ethical aspects.

Patient group: Children who met the criteria for ADHD, ie, they had developmental problems related to attentiveness, hyperactivity, and impulsiveness. The diagnosis should be made using established rating scales, which were based on criteria from the DSM-IV classification system.

Methods: Computerized training of working memory or neurofeedback.

Control interventions: Psychoeducative methods (ie, educational interventions), standard support, and placebo, eg, ordinary computer games. Studies that used waiting lists as controls were excluded.

Outcome measures: ADHD symptoms, measured with established rating scales. The effects should be judged by at least two independent information sources (eg, teachers, parents, the child). Studies with one source of information were included only if they measured the effects in follow-up after 6 months or longer.

Patient benefit

Health effects

Computerized training of working memory

❑ The scientific evidence is insufficient* to determine whether computerized training of working memory reduces the degree of inattentiveness, hyperactivity, and impulsiveness in school-aged children with ADHD.

Computerized training of working memory has been developed mainly in Sweden. Pilot studies and studies without control groups concluded that training with computerized programs has good effects on working memory. In the only randomized trial published, however, the effects were smaller. The interactive computer program was compared with a control program that was identical except that the degree of difficulty of the exercises did not increase, but remained constant. Both the parents and the teachers judged ADHD symptoms using rating scales. According to the parents, attention improved and hyperactivity decreased in the children who trained with the program that included increasing levels of difficulty. The teachers, however, found no differences between the groups. According to the parents, the difference between the groups was still significant after 3 months, even if the difference had decreased substantially.

Neurofeedback

❑ The scientific evidence is insufficient* to determine whether neurofeedback reduces the degree of inattentiveness, hyperactivity, and impulsiveness in school-aged children with ADHD.

In an international perspective neurofeedback has been studied more than computerized training of working memory. Two of the four controlled trials included in the assessment were judged to be of medium quality. One of these compared neurofeedback to a computerized program for training attentiveness. After end of training both the parents and the teachers reported that neurofeedback had reduced ADHD symptoms to a greater extent than had attentiveness training. The study did not include a follow-up.

The second study assessed the effects of neurofeedback as a supplement to a combination of methylphenidate, psychosocial support for parents, and supportive interventions in school. At 12-month follow-up, the group that had also received neurofeedback showed greater attentiveness and less hyperactivity than the group that had received only medication and psychosocial support.

The other two studies were judged to be of low quality, but the results of these studies point in the same direction as the results from the two studies of medium quality.

Since the studies used two types of neurofeedback it is difficult to draw any conclusions about the effects.

Complications and adverse effects

❑ The reviewed studies did not address the issue of complications and adverse effects (Insufficient Scientific Evidence)*.

Ethical aspects

Computerized training of working memory and neurofeedback are aimed directly at the child and thereby offer the possibility for greater integrity and autonomy.

Being able to manage one's own behavior and see its consequences – not being vulnerable to the control (or lack thereof) of others – can promote the individual's opportunity to understand and manage their life, thereby enhancing the sense of being able to actively influence one's situation. Although the computer programs offer potential advantages in terms of integrity and autonomy, it must be recognized that the effects of these methods have not been verified.

Risks for stigmatization or a sense of being singled out are small. Rather, there is a higher probability that the children receiving this type of training feel more chosen than singled out. Computers have become a part of life. Schools commonly use computer programs not only for playing games, but also for reading and mathematics. Many children with ADHD are well aware of their problems and shortcomings, and are thereby motivated to change. This motivation is, however, transient and requires support from adults to strengthen the child's perseverance.

A conceivable negative consequence would be that utilizing these methods could draw resources from other interventions for children with special needs. The greatest cost associated with computerized training of working memory is maybe the cost of time spent by parents and teachers.

Economic aspects

- ❑ The scientific evidence is insufficient* to draw any conclusions on the cost-effectiveness of the methods.

Computerized training of working memory is used mainly within the framework of schools. Only a few child psychiatry clinics use the programs. Manufacturers report that the cost for a license to cover an entire school or clinic would be 12 000 to 15 000 Swedish kronor (SEK) per year. Additional expenses include the personnel costs associated with providing support for the children.

The cost of neurofeedback could not be estimated.

*** Criteria for Evidence Grading SBU's Conclusions**

Evidence Grade 1 – Strong Scientific Evidence. The conclusion is corroborated by at least two independent studies with high quality, or a good systematic overview.
Evidence Grade 2 – Moderately Strong Scientific Evidence. The conclusion is corroborated by one study with high quality, and at least two studies with medium quality.
Evidence Grade 3 – Limited Scientific Evidence. The conclusion is corroborated by at least two studies with medium quality.
Insufficient Scientific Evidence – No conclusions can be drawn when there are not any studies that meet the criteria for quality.
Contradictory Scientific Evidence – No conclusions can be drawn when there are studies with the same quality whose findings contradict each other.

References

1. ADHD hos barn och vuxna. Kunskapsöversikt. Socialstyrelsen; 2002.
2. Remschmidt H; Global ADHD Working Group. Global consensus on ADHD/HKD. Eur Child Adolesc Psychiatry 2005;14(3):127-37.
3. Kadesjö B, Gillberg C. The comorbidity of ADHD in the general population of Swedish school-age children. J Child Psychol Psychiatry 2001;42(4):487-92.
4. Pliszka SR. Psychiatric comorbidities in children with attention deficit hyperactivity disorder: implications for management. Paediatr Drugs 2003;5(11):741-50.
5. Anderson V, Jacobs R, Anderson P, editors. Executive functions and the frontal lobes: a lifespan perspective. Hove: Psychology Press; 2008.
6. Willcutt EG, Doyle AE, Nigg JT, Faraone SV, Pennington BF. Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. Biol Psychiatry 2005;57(11):1336-46.
7. Martinussen R, Hayden J, Hogg-Johnson S, Tannock R. A meta-analysis of working memory impairments in children with attention-deficit/hyperactivity disorder. J Am Acad Child Adolesc Psychiatry 2005;44(4):377-84.
8. Taylor E, Döpfner M, Sergeant J, Asherson P, Banaschewski T, Buitelaar J et al. European clinical guidelines for hyperkinetic disorder – first upgrade. Eur Child Adolesc Psychiatry 2004;13 Suppl 1:I7-30.
9. Läkemedelsverket. Läkemedelsbehandling av ADHD – Ny rekommendation. Information från Läkemedelsverket nr 1, 2009.
10. Bergman B. Farmakologisk behandling av barn med ADHD – effektivitet och säkerhet under en längre tid. Läkemedelsverket; 2008.
11. Pelham WE Jr, Fabiano GA. Evidence-based psychosocial treatments for attention-deficit/hyperactivity disorder. J Clin Child Adolesc Psychol 2008;37(1):184-214.
12. Fabiano GA, Pelham WE Jr, Coles EK, Gnagy EM, Chronis-Tuscano A, O'Connor BC. A meta-analysis of behavioral treatments for attention-deficit/hyperactivity disorder. Clin Psychol Rev 2009;29(2):129-40.
13. Klingberg T, Fernell E, Olesen PJ, Johnson M, Gustafsson P, Dahlström K et al. Computerized training of working memory in children with ADHD – a randomized, controlled trial. J Am Acad Child Adolesc Psychiatry 2005;44(2):177-86.
14. Shalev L, Tsal Y, Mevorach C. Computerized progressive attentional training (CPAT) program: effective direct intervention for children with ADHD. Child Neuropsychol 2007;13(4):382-8.
15. Klingberg T, Forssberg H, Westerberg H. Training of working memory in children with ADHD. J Clin Exp Neuropsychol 2002;24(6):781-91.
16. 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;28(1):1-12.
17. Gevensleben H, Holl B, Albrecht B, Vogel C, Schlamp D, Kratz O et al. Is neurofeedback an efficacious treatment for ADHD? A randomised controlled clinical trial. J Child Psychol Psychiatry 2009;50(7):780-9.
18. Monastra VJ, Monastra DM, George S. The effects of stimulant therapy, EEG biofeedback, and parenting style on the primary symptoms of attention-deficit/hyperactivity disorder. Appl Psychophysiol Biofeedback 2002;27(4):231-49.
19. Drechsler R, Straub M, Doehnert M, Heinrich H, Steinhausen HC, Brandeis D. Controlled evaluation of a neurofeedback training of slow cortical potentials in children with Attention Deficit/Hyperactivity Disorder (ADHD). Behav Brain Funct 2007;3:35.
20. DuPaul GJ, Eckert TL. Academic interventions for students with attention-deficit/hyperactivity disorder: a review of the literature. Reading & Writing Quarterly: Overcoming Learning Difficulties 1998;14(1):59-82.
21. Working Memory Training in Young ADHD Children. http://www.clinicaltrials.gov/ct2/show/NCT00819611?term=NCT00819611&rank=1.

22. Project Attention Deficit Hyperactivity Disorder (ADHD) and Electroencephalography (EEG)-Neurofeedback THERapy (PANther). http://www.clinicaltrials.gov/ct2/show/NCT00723684?term=NCT00723684&rank=1.
23. Pilot Explorations of Neurofeedback Issues in Attention Deficit Hyperactivity Disorder (ADHD). http://www.clinicaltrials.gov/ct2/show/NCT00886483?term=NCT00886483&rank=1.
24. Effectiveness of a Electroencephalogram (EEG) Biofeedback for the Treatment of ADHD. http://www.clinicaltrials.gov/ct2/show/NCT00802490?term=NCT00802490&rank=1.
25. Beauregard M, Lévesque J. Functional magnetic resonance imaging investigation of the effects of neurofeedback training on the neural bases of selective attention and response inhibition in children with attention-deficit/hyperactivity disorder. Appl Psychophysiol Biofeedback 2006;31(1):3-20.
26. Carrol A, Bain A, Houghton S. The effects of interactive versus linear video on the levels of attention and comprehension of social behavior by children with attention disorders. School Psychology Review 1994;23(1):29-43.
27. Doehnert M, Brandeis D, Straub M, Steinhausen HC, Drechsler R. Slow cortical potential neurofeedback in attention deficit hyperactivity disorder: is there neurophysiological evidence for specific effects? J Neural Transm 2008;115(10):1445-56.
28. Heinrich H, Gevensleben H, Freisleder FJ, Moll GH, Rothenberger A. Training of slow cortical potentials in attention-deficit/hyperactivity disorder: evidence for positive behavioral and neurophysiological effects. Biol Psychiatry 2004;55(7):772-5.
29. Holmes J, Gathercole SE, Dunning DL. Adaptive training leads to sustained enhancement of poor working memory in children. Dev Sci 2009;12(4):F9-15.
30. Kerns KA, Eso K, Thomson J. Investigation of a direct intervention for improving attention in young children with ADHD. Developmental Neuropsychology 1999;16(2):273-95.
31. Leins U, Goth G, Hinterberger T, Klinger C, Rumpf N, Strehl U. Neurofeedback for children with ADHD: a comparison of SCP and theta/beta protocols. Appl Psychophysiol Biofeedback 2007;32(2):73-88.
32. Leins U, Hinterberger T, Kaller S, Schober F, Weber C, Strehl U. [Neurofeedback for children with ADHD: a comparison of SCP- and theta/beta-protocols]. Prax Kinderpsychol Kinderpsychiatr 2006;55(5):384-407.
33. Linden M, Habib T, Radojevic V. A controlled study of the effects of EEG biofeedback on cognition and behavior of children with attention deficit disorder and learning disabilities. Biofeedback Self Regul 1996;21(1):35-49.
34. Lubar JF, Swartwood MO, Swartwood JN, O'Donnell PH. Evaluation of the effectiveness of EEG neurofeedback training for ADHD in a clinical setting as measured by changes in T.O.V.A. scores, behavioral ratings, and WISC-R performance. Biofeedback Self Regul 1995;20(1):83-99.
35. Rossiter TR, La Vaque TJ. A comparison of EEG biofeedback and psychostimulants in treating attention deficit/hyperactivity disorders. Journal of Neurotherapy 1995;1(1):48-59.
36. Shaffer RJ, Jacokes LE, Cassily JF, Greenspan SI, Tuchman RF, Stemmer PJ Jr. Effect of interactive metronome training on children with ADHD. Am J Occup Ther 2001;55(2):155-62.
37. Shaw R, Lewis V. The impact of computer-mediated and traditional academic task presentation on the performance and behaviour of children with ADHD. Journal of Research in Special Educational Needs 2005;5(2):47-54.
38. Strehl U, Leins U, Goth G, Klinger C, Hinterberger T, Birbaumer N. Self-regulation of slow cortical potentials: a new treatment for children with attention-deficit/hyperactivity disorder. Pediatrics 2006;118(5):e1530-40.

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The complete report is available in Swedish.