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PHYSICAL ACTIVITY AND MENTAL HEALTH

A PRACTICE-ORIENTED APPROACH

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Edited by
Michel Probst & Attilio Carraro

Physical Activity and **Mental Health**

A Practice-Oriented Approach

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PHYSICAL ACTIVITY AND MENTAL HEALTH

A Practice-Oriented Approach

Edited by Michel Probst and Attilio Carraro

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Contributors

Milena Adamkova	University of Purkyně, Ústí, Czech Republic	10 Eating disorders and physical activity: a complex relationship
Jannis Alexandridis	Roseneck Clinic, Germany	12 Obesity and exercise in psychiatric patients
Marika Berchicci	University of Chieti, Italy	13 The role of physical activity in the treatment of attention deficit hyperactivity disorder
Maurizio Bertollo	University of Chieti, Italy	13 The role of physical activity in the treatment of attention deficit hyperactivity disorder
Simone Bolognesi	University of Siena, Italy	3 Mental health and physical activity: psychological and physiological mechanisms
Maud Bonanséa	Aix-Marseille University, France	11 Eating disorders in athletes
Katia E. L. Borges	University of Minas Gerais, Brazil	8 Life in movement: a physical activity program involving schizophrenic participants in community settings
Attilio Carraro	University of Padua, Italy	1 Introduction: why physical activity and mental health? 6 The role of exercise in alcohol dependence recovery 15 Physical activity for people with intellectual disability 17 Assessment and evaluation instruments of physical activity to use in people with mental health problems
Amber De Herdt	U.P.C. K.U. Leuven, Belgium	18 Sport activities in leisure time for people with psychiatric disorders
Marc De Hert	U.P.C. K.U. Leuven, Belgium	7 Physical activity in the treatment of people with schizophrenia
Seppe Deckx	Kortenberg Psychiatric Hospital, Belgium	16 Physical activity and elderly with psychiatric disorders
Andrea Fagiolini	University of Siena, Italy	3 Mental health and physical activity: psychological and physiological mechanisms
Angela Favaro	University of Padua, Italy	2 Epidemiology and diagnostic criteria
Ilaria Ferri	University of Padua, Italy	15 Physical activity for people with intellectual disability 18 Sport activities in leisure time for people with psychiatric disorders
Luciano Antonio Bernardis Fiorellini	Casa di Cura Parco dei Tigli, Italy	4 Psychopharmacology and physical activity
Markus Gerber	University of Basel, Switzerland	5 The role of exercise in the generation and regulation of stress
Erica Gobbi	University of Padua, Italy	15 Physical activity for people with intellectual disability

Arianna Goracci	University of Siena, Italy	3	Mental health and physical activity: psychological and physiological mechanisms
Heather Hausenblas	University of Florida, USA	10	Eating disorders and physical activity: a complex relationship
Jan Knapen	U.P.C. K.U. Leuven, Belgium	7	Physical activity in the treatment of people with schizophrenia
		9	Exercise for depression and anxiety: an evidence based approach and recommendations for clinical practice
Cristophe Maïano	Aix-Marseille University, France	14	Sport and adolescents with conduct disorders
Johana Monthuy-Blanc	University of Sherbrooke, Canada	10	Eating disorders and physical activity: a complex relationship
		11	Eating disorders in athletes
Felipe A. S. Moura-Lima	University of Minas Gerais, Brazil	8	Life in movement: a physical activity program involving schizophrenic participants in community settings
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Uwe Pühse	University of Basel, Switzerland	5	The role of exercise in the generation and regulation of stress
Ruud van Winkel	U.P.C. K.U. Leuven, Belgium	7	Physical activity in the treatment of people with schizophrenia
Davy Vancampfort	U.P.C. K.U. Leuven, Belgium	7	Physical activity in the treatment of people with schizophrenia
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The role of **physical activity** 13 in the treatment of attention deficit **hyperactivity disorder**

Marika Berchicci & Maurizio Bertollo

13.1 INTRODUCTION

The Story of Fidgety Philip is a book of children's poems, published in 1845 and written by a German psychiatrist, Heinrich Hoffman. He described a child called Philip that "[...] won't sit still; he wriggles and giggles, [...] swings backwards and forwards, and tilts up his chair [...]" Hoffman provided a perfect description of what we know as Attention Deficit and Hyperactivity Disorder (ADHD), predominantly hyperactive-impulsive type. Half a century later, in 1902, Sir George F. Still published three lectures to the Royal Academy of Physicians in London in which he described a group of 43 children with behavioral problems. He suggested that the cause was genetic, not poor child rearing. The complex symptomatology of ADHD has not changed since the first descriptions. However, the historical evolution of the ADHD concept firstly emphasized the hyperactivity and poor impulse control (American Psychological Association [APA], 1968); subsequently, neuropsychological methods and techniques evidenced behavioral inattention and performance deficits of attention (APA, 1980). Overall, ADHD is currently described as a neurobiological disorder characterized by chronic and developmentally age-inappropriate symptoms of inattention, hyperactivity, and/or impulsivity, which occur for at least six months in at least two domains of life, beginning prior to the age of 7 years (APA, 2000). Nowadays, ADHD is the most prevalent childhood psychiatric disorder (Nair et al., 2006). The symptoms, usually associated with a variety of psychiatric comorbidities, are related to a catecholaminergic dysfunction in the prefrontal cortex and striate areas, as shown by neuroimaging and neurobiological studies. Children

with ADHD exhibit also a peripheral catecholamine (CA) deficiency, which can be detected during biochemical, physical, and cognitive tests (Medina et al., 2010). The Fourth Edition of the Diagnostic and Statistical Manual of Mental Disorder (APA [DSM-IV-TR], 2000) differentiates three subtypes of ADHD: predominantly inattentive (ADHD-I), predominantly hyperactive-impulsive (ADHD-H), and combined (ADHD-C). ADHD affects 5% to 10% of school-aged children; boys are six to ten times more likely to be referred for the disorder, and three to four times more likely to be diagnosed when compared to girls (Willcutt & Pennington, 2000). Ethnic group, family, and socio-environmental factors influence the recognition of ADHD through the degree of acceptance of externalizing behavioral traits and informant agreement (Stefanatos & Baron, 2007). An alternative diagnostic criteria used in the diagnosis of ADHD is the ICD-10 Clinical description (WHO, 1992). Basically it is very similar to the DSM-IV, but its classification **changes the name** in *hyperkinesia*. Current research suggests that neurobiological factors play an important role in the development of ADHD. More specifically, the cerebellum (see Cherkasova & Hechtman, 2009 for a review), the frontal regions, the cingulate cortex and associated striate regions, as well as the basal ganglia and the parietal cortices, are frequently cited as neural correlates of ADHD (Dickstein, Bannon, Xavier, Castellanos, & Milham, 2006; Sowell, Peterson, Thompson et al., 2003). An additional hypoactivity has been found in the dorsal anterior cingulate cortex that facilitates complex and effortful cognitive processing and modulates reward-based decision-making, as documented by two more recent meta-analyses (Dick-



Figure 13.1 - Pool of balls. Children having fun time in a pool of balls. Free play could have positive impact on emotion management and imagination.

stein et al., 2006; Valera, Faraone, Murray, & Seidman, 2007). Moreover, MRI studies comparing children with ADHD to controls found that children with ADHD had all four lobe volumes smaller than the controls (see Krain & Castellanos, 2006 for a review). However, the most structural differences are in the prefrontal cortex. The dorsolateral prefrontal cortex (DLPFC) which is the region that affects vigilance, attention shifting, planning, executive control, selective and divided attention, and working memory (Duncan & Owen, 2000), in conjunction with the ventrolateral prefrontal cortex (VLPFC), which is linked with behavioral inhibition and has documented involvement in stop-signal task (Aron, Fletcher, Bullmore, Sahakian, & Robbins, 2003), represent a core deficit in frontal lobe function that underlies its various cognitive and behavioral manifestations in ADHD (see Bush, Valera, & Siedman,



Figure 13.2 - Free climbing. A little child is climbing a rock. Free climbing helps children to consolidate basic skills and to cope with risk situations.

2005 for a review). These structural and functional dysfunctions may reflect the poor executive function in children with ADHD. The role of executive function involves central control processes, such as planning, organizing, shifting and sustained attention, regulating alertness, modulating emotion, facilitating working memory, and having the ability to self-regulate actions. One comprehensive theory well accounted for in literature is the *Barkley's hybrid model* (Barkley, 1997) of ADHD that identifies behavioral inhibition as the core executive function affected in ADHD. More specifically, he refers to the difficulty of stopping a habitual and dominant response, and to alert their response following corrective feedback and goal-directed motor behavior (Dawson & Guare, 2004), as well as diminished self-control, timing, flexibility, and novelty (Barkley, 1997). Evidence supports that these executive function deficiencies involve numerous impairments in social life, such as disruptive behavior, cognitive deficits, higher frequency of risk taking behavior, difficulties in family and peer relationships, and also an increased risk of obesity. Moreover, there is a characteristically higher incidence of anxiety and depressive symptoms, stemming from low self-esteem (Barkley, 1990; Weiss & Hechtman, 1993). Executive function deficits are also associated with poor academic performance, which places a heavy load on the school system (Altemeir & Horwitz, 1997). ADHD has long-term negative outcomes for many children, including decreased educational attainment, work performance, and occupational stability (Barkley, 2002; Barkley, Fischer, Smallish, & Fletcher, 2006). Learning problems are an especially common comorbid diagnosis in ADHD among school-aged children (Pliszka, 2007), which contribute to academic performance and productivity. In addition, writing deficits (Marcotte & Stern, 1997), central auditory processing problems (Breier, Gray, Klaas, Fletcher, & Foorman, 2002), and speech and language disorders often co-occur with ADHD (Bruce, Thernlund, & Nettelbladt, 2006). Further, motor coordination signs were found in 60% of children with ADHD when compared to controls, with excessive mirror movements, difficulties in the execution of complex motor sequences and slower reaction time (Stefanatos & Baron, 2007). A considerable number of children with ADHD may have difficulties when performing locomotor and object control skills (Harvey & Reid, 2005), as well as

in timing. Furthermore, in a recent study Barry et al. confirmed the existence of hypoarousal in ADHD (Barry, Clarke, McCarthy, Selikowitz, Macdonald, & Dupuy, 2012).

13.2 PHYSICAL ACTIVITY AND ADHD: THEORETICAL OVERVIEW

Multidisciplinary literature has documented the beneficial effect of physical exercise on brain functions and cognition (Hillman, Erickson, & Kramer, 2008). Exercise not only improves physical health, but exerts its positive effects on the cognition at the molecular, cellular, behavioral and systemic levels. Further evidence indicates that participation in sports activity has been associated with the reduction of mental disorders (e.g. anxiety and depression) and physical disorders (e.g. cardiovascular disease, obesity, breast and colon cancer) across the lifespan.

There is evidence that aerobic physical activities, which improve cardio-respiratory fitness, are beneficial to cognitive function and selectively improve executive function performance in the general population (Etnier, Nowell, Landers, & Sibley, 2006), in healthy older adults (Angevaeren, Aufdemkampe, Verhaar, Aleman, & Vanhees, 2008; Colcombe & Kramer, 2003), and in children (Sibley & Etnier, 2003). However, physical activity has been relatively unexplored as a behavior that could benefit children with ADHD.

An overview of current literature on the relationship between physical activity and cognition will be provided as a rationale for approaching an understanding of the affect on children. For example, older adults tend to experience declines in executive processes coupled with selective increased brain tissue density and loss of frontal, parietal, and temporal cortices, which were found reduced as a function of cardiovascular fitness (Colcombe et al., 2003). In adjunction, higher levels of aerobic fitness were found associated with increased hippocampal volume and better memory function in older humans (Erickson et al., 2009). Exercise also enhances neurogenesis; a positive correlation was found between physical exercise and hippocampal neurogenesis (Winter et al., 2007), raising the hypothesis that exercise improves learning through its effect on the hippocampus (Fabel & Kempermann, 2008), changing the function of neurotransmitter systems.

Animal studies and studies with older adults demonstrate that the deficiencies of central catecholamines in cognitive (Anderson et al., 2000), biochemical (Girardi et al., 1995), and physical (Wigal et al., 2003) tests are decreased after physical activity (Hillman, Castelli, & Buck, 2005). Up-regulation of dopamine and norepinephrine were found in animal studies. In addition to catecholamines, the release of neurotrophic factors, like brain-derived neurotrophic factor (BDNF), nerve-growth factor (NGF), or insulin-like growth factor (IGF-1) is increased in the brain after daily physical exercise.

In particular, serotonin receptors activated by physical activity enhances BDNF expression in hippocampal cells (Vaidya et al., 1997) and BDNF treatment increases tryptophan hydroxylase expression in raphe nucleus neurons (Siuciak et al., 1998). This complex neurobiological mechanism plays a key role in the learning process (Cotman & Berchtold, 2007). A similar picture has emerged in human studies indicating that physically active behaviors influence cognitive functions and the supporting brain structures.

In humans, the P300 component of event-related potential (ERP) had larger amplitude and a shortened latency in attentional challenging tasks. It seems that in humans, physical exercise affects executive functions more than other cognitive processes (Colcombe & Kramer, 2003). Lambourne (2006) found that the working memory capacity of young adults with a high level of fitness differed from those who did not practice exercise.

This is one of the few studies investigating the relationship between cognition and physical activity in adolescents. Overall these findings suggest that the exercise-induced increase of catecholamines and neurotrophic factors might improve learning and induces changes in activity of frontal lobes, which facilitate mental concentration, decision making, memory, planning, and creativity (Caterino & Polak, 1999; Winter et al., 2007).

There is considerable support for the view that regular physical exercise is associated with elevation in mood states (Tomprowski, 2003) and modulates stress and anxiety, which have detrimental effects on memory and learning, contributing to behavioral problems (Adlar & Cotman, 2004; Howells, Russell, Mabandla, & Kellaway, 2005).

Physical activity has been found to positively impact many of the same neurobiological and cognitive factors that are implicated in ADHD. Intense exercise increases blood flow and heightens levels of endorphin and acetylcholine in the brain. The increase in endorphin levels promotes a feeling of wellbeing and reduces the effects of certain secondary symptoms such as depression. Exercise is also effective at reducing hyperactivity and restlessness by making it easier to sit still for a longer period of time.

Physical activity as an intervention in the classroom has been found to impact some of the difficulties that students with ADHD may present, such as the target child's ability to focus, and contributes to improved achievements in math class. For example Azrin, Vinas, and Ehle (2006) suggest that for children with hyperactivity, vigorous scheduled physical activity might be effective to reinforce calmness and increase academic performance.

Another benefit of exercise is that it may discourage children from other endeavors that may make ADHD symptoms worse. The best examples of these wrong behaviors are television, video, and computer games. Television, video, and computer games take up a lot of time that could be used for activities such as interacting with others and involvement in physical activity programs. These sedentary activities promote passivity, give immediate gratification, and promote solitary behavior.

A considerable number of children with ADHD may have difficulties when performing locomotor and object control skills (Harvey & Reid, 2005). Most children with ADHD seem to be novice in movement skill performance and even though they know different action terms, they are not able to refer to the terms with their peers in an appropriate manner, as if they have only a superficial understanding of both movement skills and the purpose of the actions. Such differences in skill confirm a substantial atypical development of procedural and declarative knowledge in children with ADHD (Harvey et al., 2009), as already reported for adults with physical disabilities (Williams & Davids, 1995).

Medina et al. (2010) found better reaction times and lower impulsivity after exercise than that observed among normal individuals immediately. Their results also confirm the assumption that the child's attention deficit can be minimized through

physical activity independently from pharmacological medication.

13.3 TREATMENTS

ADHD treatment is based on a multimodal approach that combines psychosocial intervention and medical therapy (Kutcher et al., 2004), even though for many years, particularly in the United States, *pharmacotherapy* has been the most applied intervention in ADHD treatment. The stimulants represent the class of psychotropic medication most commonly prescribed for children with ADHD, which are considered to be catecholamine agonists. It is important to note that while stimulants are effective in the management of the behavioral and cognitive symptoms associated with ADHD, such as inattention, over-activity and impulsivity, there is little known about the long-term changes in academic achievement, the wide individual variation in therapeutic effectiveness, and the optimal dosage level. Another criticism of stimulant drug therapy is represented by the side effects, such as sleep disturbance, appetite suppression, headaches and stomachaches, irritability, motor tics, and social withdrawal (Pliszka, 2000). Moreover, medication does nothing to promote healthy lifestyle behaviors.

Since it is well recognized that children with ADHD devote little time to play or be active with other children, *play therapy* should be a good additional treatment (Davenport & Bourgeois, 2008; Johnson, Rasbury, & Siegel, 1997). Psychologists have determined that a child expresses a great deal through play, which is the idea behind play therapy. It allows children to play in a controlled environment, leaving the adults to observe their behavior. For example sensorimotor play involves the different senses (e.g. tactile, acoustic, and visual experiences, kinaesthetic and proprioceptive stimuli). Practice play contributes to the development of coordinated motor skills needed for later structured game playing and sport. In symbolic play, also called make-believe play, a child transforms an object into other objects and acts toward them. The social play revolves around social interaction with peers. Constructive play occurs when a child uses their imagination and skills to create a product. The play therapy develops problem solving skills, imagination, fine motor skills, and self-esteem, selectively impaired in ADHD, thus can be beneficial in achieving a good outcome.



Figure 13.3 - Tumble play. Children involved in tumble play have valuable opportunities to build social and emotional bonds.

Recently, some authors and clinicians have introduced *neurofeedback*, or EEG biofeedback in the therapy setting (Arns, De Ritter, Strehl, Breteler, Coenen, 2009; Leins, Goth, Hinterberger, Klinger, Rumpf, & Strehl, 2007), even though it was first applied in 1976 by Lubar and Shouse. EEG activity from ADHD children presents different waveforms when compared to control children. Specifically, the EEG brain waves tend to be of larger amplitude and show excess theta activity along with lower amounts of beta activity (Lubar, 1991). This pattern of brain wave activity usually indicates a sleep or day dreaming state, rather than an alert and focused state. The goal of EEG biofeedback training is to alter these abnormal brain waves by decreasing theta waves, while simultaneously increasing beta waves. In EEG biofeedback training, the therapist explains to the child the connection between what is happening in their cortex and what is recorded on the EEG. Using an electroencephalograph to monitor the brain waves and a system of positive reinforcement, the children learn how to make their brains become more attentive. The result is that there is a significant reduction in ADHD symptoms and improvements in behavior, relative to how well the children learn to control their own brain function. When an ADHD child is given a task requiring attention, instead of increasing beta waves, sometimes he increases theta waves, the day dreaming brain wave. These children have what is known as a high theta/beta ratio and neurofeedback technique could normalize this ratio (Fox, Tharp, & Fox, 2005; Fuchs, Birbaumer, Lutzenberg, Gruzelier, & Kaiser, 2003; Gevensleben et al., 2009).



Figure 13.4 - In pair transport. Children have to organize their action with those of a partner to realize the transportation of the ball. This activity requires coordination, precision and couple communication.

Behavioral management, which includes cognitive behavioral therapy, parent-training, classroom, academic and peer-related interventions, has also been widely studied for children with ADHD.

Despite the strength of evidence for behavioral interventions, it may be unsuccessful due to the need for continued intervention, the complexity of the therapy, dependence on cooperation between parents and teachers, and the relatively high cost of implementing behavioral interventions (Barabasz & Barabasz, 2000).

Thus, behavioral therapies are typically not adequate for bringing children into normal ranges of functioning (Antshel & Remer, 2003; Fiore, Becker, & Nero, 1993; Hinshaw, 1992); additionally, stimulant medications do not show improvement in basic physical skills and involve numerous side effects (Rowland, Lesense, & Abramowitz, 2002).

Despite combined treatment necessitating the involvement of multiple professionals in the care of children with ADHD and their families, it represents the gold standard in ADHD treatment and is often recommended as the first-line treatment option due to the many problems faced by children with ADHD. The desirable treatment should be socially valid, functionally based, should be specifically tailored to the identified disorder subtype and suited to the child, family and socio-environmental context. Physical activity reflects these features, and it may represent an additional treatment intervention and can prove helpful in minimizing a number of primary and secondary symptoms.

13.4 SUGGESTIONS FOR PHYSICAL ACTIVITY INTERVENTION

Exercise works in a positive way to regulate behavior, improve mood, develop coordination, improve self-esteem, focus attention, and regulate activation. In particular, a specific type of physical activity is *movement therapy*, which is based on sensorimotor activity, like many pedagogical interventions. The latest treatment of ADHD espouses sport as an alternative to prescription drugs. This approach advocates body training and daily walks in natural surroundings such as gardens or woods. It is claimed that the above-mentioned approach can enhance cognitive processes and free tensions in feelings. Indeed, psychomotor education encourages the use of all senses and promotes movement, emphasizing the link between physical and emotional behavior. Physical activity also induces healthy habits. Disorganization, stress, and poor sleeping are all symptoms of ADHD that make it hard to be active and healthy. Exercise reduces anxiety, impulsiveness and hyperactivity associated with ADHD, improves sleep quality and contributes to weight management. Working out empowers persons to release pent-up energy. Post-exercise elevation of brain chemicals improves concentration and may make it easier for people to make lifestyle choices after a workout. Scheduling workouts and adhering to that schedule creates order and establishes a routine, both of which benefit someone suffering with ADHD.

The literature agrees with suggesting at least 30 to 60 minutes per day of moderate to vigorous physical activity for ADHD children, in order to regulate adrenergic system and to use physical activity as catecholaminergic agonist, in favor of a reduction of pharmacological prescriptions.

The lack of clinical randomized control study, which uses the psychomotor intervention, along with structured adapted physical activity and/or exercise, is a limitation in this area. There is also a need for shared procedures in physical activity settings. In this paragraph we would like to advise and propose a first step toward the understanding of procedures and activities that may attenuate ADHD symptoms, stemming from the six characteristics most frequently seen in children with ADHD. These are hyperactivity, perceptual motor impairment, emotional instability, general coordi-

ination deficit, disorders of attention, and executive function impairments.

Recently, Verret, Guay, Berthiaume, Gardiner, & Béliveau (2010) tried to prove the effect of a structured physical activity program, which may have clinical relevance to the functional adaptation of children with ADHD. In particular, Tantillo and colleagues (2002) developed physical exercise and sport activity programs specifically designed to improve psychomotor ability, cognitive processes or biochemical level.

A successful approach to adapted physical activity programs with children needs to start with skill development. Different programs have been used to improve psychomotor abilities and skills development. For instance, the psychomotor tradition refers to Le Boulch (1985), Vayer (1982) and Aucouturier (2005) programs, whereas in a school educational context there are the physical education activities suggested by Pangrazi (2004), and in sport education programs the proposal of Siedentop and Tannehill (2000).

In relation to the definition of a structured program of physical activity for ADHD children, the problems lie not only in the exercises or its contents, but also to the procedure and the teaching strategies. For instance, Hallowell and Ratey published an interesting brochure titled “50 Tips on the Classroom Management of Attention Deficit Disorder.”

Based on our experience, we believe that a good theoretical framework and applied setting for defining a structured physical activity program is the Five Step Strategy (FSS). The FSS is a meta-strategy that has been developed specifically for enhancing the learning of self-paced motor skills (Singer, 1988). The FSS emphasizes the appropriate use of cognitive processes before, during, and after a skill performance. It is a sequential organization of five stages (Textbox 13.1). The FSS should help individuals who are learning a new motor skill to increase their self-confidence, to concentrate on the task at hand, and to create a self-monitoring system. The adaptation of this strategy to children affected by ADHD is very useful, because it follows the same metacognitive strategies used in cognitive behavioral therapy, extended to motor and physical activity.

FSS theoretical framework application could represent a useful structure for ADHD children, implementing specific exercise, mainly derived from the psychomotor and movement therapy tradition, as described in Table 13.1.

The five stages of FSS to enhance the learning of self-paced motor skills

1. *Readying*: helps individuals to create an optimal arousal state before performance by identifying and controlling emotions that may be disruptive to performance itself. ADHD children need higher levels of arousal than others because they are hypoactivated (Douglas, 1988). Readyng can help improve their arousal levels to more appropriate and controllable levels, prior to cognitive and behavioral performance as well.
2. *Imaging*: involves visualizing the desired outcome of the intended act (i.e. the correct execution of the task). Imaging has been shown to facilitate motor-skill acquisition, and it may be particularly important for ADHD children, because they tend to have problems with self-regulation mechanisms (Schunk & Zimmerman, 2003).
3. *Focusing*: involves orienting one's attention to a relevant cue. This type of attentional focus should help individuals to block out internal and external distractions that impede learning (Broadbent, 1982). Since ADHD children have a more difficult time attending to important stimuli relevant to the task and blocking out external distractors, this sub-strategy should help them focus better on the task at hand.
4. *Executing*: involves performing the task with a clear mind (i.e. without focusing on the mechanics of the skill).
5. *Evaluating*: involves the learner in analyzing the quality of performance. Analyzing what was done right and what was done wrong is essential to learning a skill. This sub-strategy promotes a self-monitoring system and the adjustment of future performances based upon the assessment of previous performance outcomes.

13.5 SUMMARY

Hoffman, as early as 1845, provided a perfect description of what we know as Attentional Deficit and Hyperactivity Disorder (ADHD), currently described as a neurobiological disorder characterized by chronic and developmentally age-inappropriate symptoms of inattention, hyperactivity, and/or impulsivity, which occur for at least six months in at least two domains of life, beginning prior to the age of 7 years. Nowadays, ADHD is the most referred childhood psychiatric disorder, affecting 5% to 10% of school-aged children. The symptoms, usually associated with a variety of psychiatric comorbidities, are related to a catecholaminergic dysfunction in the prefrontal cortex and striate areas, as shown by neuroimaging and neurobiological studies, as well as in the cerebellum. The structural and functional dysfunction, especially in the prefrontal brain, may reflect the poor executive function in children with ADHD. The role of the executive function impaired in ADHD involves central control processes, such as planning, organizing, shifting and sustained

attention, regulating alertness, modulating emotion, facilitating working memory, and having the ability to self-regulate actions. Evidence supports that these executive function deficiencies involving numerous impairments in social life, such as disruptive behavior, cognitive deficits, higher frequency of risk taking behavior, difficulties in family and peer relationships, and an increased risk of obesity. Executive function deficits are also associated with low self-esteem and a consequent higher incidence of anxiety and depressive symptoms, and with poor academic performance, which places a heavy load on the school system. ADHD has long-term negative outcomes for many children, including decreased educational attainment, work performance, and occupational stability. Further, motor coordination signs were found in 60% of children with ADHD when compared to controls, with excessive mirror movements, difficulties in the execution of complex motor sequences and slower reaction time, difficulties when performing locomotor and object control skills, and difficulties in timing. Combined treatments represent the gold standard in

Table 13.1 - ADHD: physical activity intervention

<i>Area of intervention</i>	<i>Rationale</i>	<i>References or theoretical framework</i>	<i>Program focus</i>	<i>Suggested exercises</i>
Behavior and cognitive functions	Exercise improves cognitive ability and regulates behavior	Verret, Guay, Berthiaume, Gardiner, and Béliveau (2010)	Aerobic activity, strength training, and motor skills training	To perform at least a 45-min exercise routine 3 times per week supervised by a PE teacher maintaining moderate to vigorous intensity in each session, possibly using heart rate monitor.
Calming hyperactivity	Physical activity to reinforce calmness	Azrin, Vinas, Ehle (2006); Lapierre and Aucouturier (1978)	Locomotor skills Movement	Run and stop on signal; change direction on signal; run with different steps; run at different speed.
Arousal, activation focusing and emotion regulation	Modulate the arousal level: high activation can be lowered, high and low arousal level can be reinterpreted, low activation felt as unpleasant can be increased	Bertollo and Carraro (2003), based on IZOF model (Hanin, 2000) and Reversal Theory (Kerr, 1987)	Relaxation Muscle to mind Mind to muscle	Laying into ball-pond. Breathing exercises or progressive relaxing (Jacobson). Meditation, visualization, passive relaxing (A.T.).
	Develop the ability to concentrate and be aware of feelings in a controlled, coordinated, and skilful manner, promoting psychosocial development	Therapeutic Eurhythm (TE) (Majorek, Tüchelmann, & Heusser, 2004)	Coordination and skills Rhythms Sounds and speech	Throw a ball or a rod to each other to a rhythmically spoken poem; move a copper ball with the fingers of one or two hands; carry out different patterns of jumping over rods; walk the rhythm, the tact and the meter of a poem; clap and/or walk different types of rhythms; make specific patterns of movements with arms, hands, fingers, and legs to spoken letters in a sequence, e.g. BMDNRL; jump or execute specific arm movements for the five vowels.
Perceptual motor skill, general motor development	Enhance the ability to receive, interpret and respond successfully to sensory information, throughout movement activity	Frostig (1972); Le Boulch (1979); Vayer (1982); Pangrazi (2004)	Gross motor activities	Rolling, crawling, walking, running, jumping and landing, hopping, skipping, galloping, leaping.
			Vestibular activities	Roll over balls, forward and backward rolls, spinning, balance, scooter boards, skipping with and without ropes, jumping activities.
			Visual motor activities	Manipulation, such as eye-hand coordination (e.g. striking), eye-foot coordination activities (e.g. kicking), ball activities (e.g. throwing and catching).
			Auditory motor activities	Temporal awareness. Singing, rhymes and chants. Responding to auditory cues/commands.
			Tactile activities Lateralization activities	Massage, direct touch, and rolling. Bilateral movements, either simultaneous or parallel. Unilateral movements (i.e. one side of the body). Cross lateral movements, such as simultaneous movement of different limbs on opposite sides of the body (e.g. crawling).

(continued)

			Awareness	Body awareness, such as that of one's hands, feet, arms, elbows, stomach, back, etc. Spatial awareness, such as the use of topological and Euclidean concept wherein the child explores the space using different types of locomotion.
General coordination	Coordination improvement for the awareness of physical self, emotional and physical security, increase in confidence, and awareness of environment	Rintala, Pienimaki, Ahonen, Cantell, and Kooistra (1998); Gross motor training (Kiphard, 1994); Developmental Movement Method (Sherborne, 1990)	Gross motor training	Walk and run, climb a ladder, jump on a trampoline, rhythmic jump on the floor, skip with a rope, dynamic balance walking tasks, throw at a target, kick and strike a ball, jump over and crawl under a bar, static balancing tasks, rolling tasks; to be completed 2-3 times per session. Awareness of the body (using one's hands, feet, arms, elbows, back, etc.) and space (crawling, walking, running in the room, etc.), work in pairs (rolling, swinging, pulling, etc.) and as a group (making a circle/tunnel and moving, etc.).
	Enhance motor learning in general, in particular the transfer of skills to activities of daily living for DCD children. Also useful for ADHD children	Neuromotor Task Training (Schoemaker & Smits-Engelsman, 2005)	Body awareness training	The tasks are different for each child, depending on its individual needs as well as the expectations, capabilities, and motivation of both the child and its parents/guardians. The focus of exercise is on the interactions between the child and its environment that will result in acquiring new or improved motor functions, and special attention is paid to how therapists teach the children.
Attention, memory and cognitive process	The concentration required during physical activity to one's bodily movement increases post-exercise focus, attention and memory	Berchicci and Bertollo (2009)	Sports	Taekwondo, martial arts, ballet, yoga, dance, or any physical activity that requires deep mental concentration.
			Other physical activities	Catch just the blue ball, or the all the balls except the red one. Inverse repetition of Hand's gesture.
Executive functions and learning	Physical activity to improve brain chemicals	Gapin and Etnier (2009)	Aerobic exercise	Acute bouts of moderate aerobic exercise (i.e. 20 min).
	Complex program of integrated sensory stimulation incorporating visuomotor and vestibular therapy. It is created specifically to stimulate and improve the efficiency of the cerebellum	Dyslexia, dyspraxia and attention disorder treatment (DDAT) (Mackie et al., 2007)	Visuomotor and vestibular therapy	Balance board; throw and catch of bean bags (including throwing from hand to hand with careful tracking by eye); practice of dual tasking; stretching and coordination exercises.

ADHD treatment and are often recommended as the first-line treatment option due to the many problems faced by children with ADHD. Behavioral therapies are typically not adequate in bringing children into normal ranges of functioning, and stimulant medications do not show improvement in the basic physical skills and involve numerous side effects. The desirable treatment should be socially valid, functionally based, should be specifically tailored to the identified disorder subtype and suited to the child in a family and socio-environmental context. Physical activity reflects these features, and it may represent an additional treatment intervention and can be proven helpful in minimizing a number of primary and secondary symptoms. Exercise works in a positive way to improve mood, develop coordination, improve self-esteem, and release the excess energy that is so common in hyperactive children; all beneficial in managing attention deficit disorder with hyperactivity.

Physical activity has been found to positively impact many of the same neurobiological and cognitive factors that are implicated in ADHD. Intense exercise increases blood flow and heightens levels of endorphin and acetylcholine in the

brain. The increase in endorphin levels promotes a feeling of wellbeing and reduces the effects of certain secondary symptoms such as depression. Exercise is also effective at reducing hyperactivity and restlessness by making it easier to sit still for a longer period of time. Physical activity as an intervention in the classroom has been found to impact some of the difficulties that students with ADHD may present, such as the ability to focus, and contributes to improved achievements in math class.

The *Five Step Strategy* (FSS), which is a Cognitive Behavioral Educational Intervention, is a meta-strategy that has been developed specifically for the enhanced learning of self-paced motor skills (Singer, 1988). It is a sequential organization of five processes: *readying*, *imaging*, *focusing*, *executing*, and *evaluating*. The FSS should help individuals who are learning a new motor skill to increase their self-confidence, to concentrate on the task at hand, and to create a self-monitoring system. FSS theoretical framework application could represent a useful program for ADHD children, implementing specific exercise, mainly derived from the psychomotor and movement therapy tradition.

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