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Specifics of Motor Skills and Motor Learning in Children with ADHD*

Abstract

The thesis deals with an analysis of the theoretical basis of a systematic approach to defining motor skills and motor-learning processes in children with attention deficit and hyperactivity. It is based on various methodological approaches and analyses that help us identify the specific nature of motor ability in children with ADHD. We analyse in detail the principles and determinants of motor-skill development in the ontogenesis of children with ADHD, who have limited proprioception and movement planning, bilateral integration, and psychomotor adaptation. An effort has been made to show the mutual effect motor skills and mental skills have on the bilateral formation of cognitive processes and motor-learning processes, and to suggest potential solutions to behavioral and educational, and social and emotional problems in practice.

Keywords: limitations of proprioceptive perception, psychomotor adaptation, ontogenesis, ADHD

Introduction

Motor hyperactivity is considered to be a key aspect of ADHD and is characterized by, for instance, excessive motor activity, and restlessness (Zametkin, Ernst, 1999). Hyperactivity is manifested in a disproportionate level of aimless, excessive motor activity, and in elevated speech levels and volumes. Children with ADHD are noticeably clumsy and have impaired fine and gross motor skills and sensory motor skills. They exhibit inappropriate and unnecessary body movements, motor restlessness, and fidgeting (Kirby, 2010). Volemanová (2013) has suggested this state could be caused by the retention of primary reflexes such as the Moro Reflex, asymmetric tonic-neck reflex, tonic labyrinthine

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reflex and the Galant spinal reflex. The last of these manifests itself in an irritation of the lumbar area, and frequent, visible movement of the lower and upper limbs, an inability to stand still, problems playing games or doing group activities can also be observed.

Research findings verifying that children with ADHD have impaired motor skills and abilities have led to a number of hypotheses. The first set of hypotheses assumes that motor deficits form part of the basic symptomatology of ADHD, the second set considers motor-skill problems to be a manifestation of a secondary disorder (Developmental Coordination Disorder, DCD), which has a high prevalence among children with ADHD. This disorder manifests as a serious impairment in the motor-learning processes and the practical realization of motor skills. Motor-skill impairment is frequently recorded in populations of children with ADHD (Barkley, 2006), with 47% to 69% of children with ADHD exhibiting a motor-coordination deficit.

Tseng a. oth. (2004) stated that attention and impulsivity control are good predictors of a motor-skill deficit in children with ADHD and account for 55.9% of variation. Fliers et al. (2009) identified a low-to-very low level of motor development in 52% of children with ADHD. Based on clinical and epidemiological studies, they suggested that 30–50% of children with ADHD have specific motor-skill problems (Fliers a. oth., 2009). Furthermore, these motor-skill deficits in children with ADHD can partly be explained by neurological abnormalities in the brain structures associated with motor control (the cerebellum and basal ganglia).

Goulardins a. oth. (2013) suggested that the onset of motor skills is delayed by almost one year compared with the chronological age of the child population of ADHD. Descriptions of the specific deficits in fine and gross motor skills, and the link between physical performance and ADHD symptoms, are based on a number of studies (Pitcher, Piek, Hay, 2003; Tseng a. oth. 2004). Research findings have indicated low levels of balance and kinesthetically differentiated motor abilities and motor skills as well as deficits in motor-learning ability (Dahan a. oth., 2018).

Conditions of motor-skill development in children with ADHD

Motor skills are defined as the combination of all a person's potential physical abilities that, in conjunction with constitutive and mental factors, enable the person to perform various physical movements. During ontogenesis a person's motor skills are an integral part of the formation of the person (Měkota, Novosad, 2005). Variations in an individual's motor capacity are the result of genetic makeup and external environmental influences. It is well-known that an in-

dividual's motor development does not occur uniformly. Motor-skill development is dependent on the functioning of the nervous system, ossification, and muscle development. According to Adolph (2018) the ontogenesis of motor skills in children with ADHD has many specific features. Psychomotor development begins automatically as a result of genetic programming. Differences in motor-skill development and the typical symptoms of ADHD syndrome can be identified in the various developmental phases, as has been done by Paclt (2007), and Chovanová, Majherová, Ružbarská (2015).

Parents and those around the child often lack objectivity. The child's feelings of success and failure are often dependent on their surroundings. According to Szabová (2001) adults are quick to chastise children with ADHD and restrict their physical activities, saying, "You won't be able to! You'll fall! You're not to do that! That's dangerous!..." Children with ADHD have difficulty finding satisfaction in their activities, as their physical skills do not develop adequately. In fact, the feelings of fear and defensiveness triggered by adults restrict the children and prevent them from developing. Children with ADHD should be provided with the stimuli and support they require to develop their physical skill, and which take their developmental and individual abilities into account (Chovanová, Lenková, 2013).

Research by Pitcher, Piek, Hay (2003), Fliers a. oth. (2008), and Polderman, van Dongen, Boomsma (2011) showed that, in addition to cognitive impairment, coordination and motor skills frequently develop late in children with ADHD. Deficits in fine and gross motor skills often appear at the age of 6 to 10 years. No gender differences have been observed. Children with ADHD are often dictatorial and impatient during activities. They have to learn to wait in line, and to win and lose. Motor coordination problems lead to the child lagging behind and making mistakes when performing movements. If they break the rules, they are unaware of doing so. They are laughed at, and lose self-confidence and self-assurance. Injury rates increase. Delayed motor skills can therefore develop into social, emotional and learning, and childrearing problems (Kurtz, 2015).

Diversification of motor skills

Motor skills include motor ability, motor habits, motor skills and experience, and these are subject to the person's somatic, neurophysiological, and intellectual development in addition to character and social relationships. The development of motor skills is a complicated process. It is determined by the influence of many endogenous and exogenous factors. The determining endogenous factors include heredity and genetic disposition; in other words, the organism's internal ability to perform movements and to learn motor activities. Motor

skills are determined and influenced by exogenous factors as well, such as upbringing, environment, and the individual's motor activities.

Gross motor skills refer to the locomotion of the whole body and limb movements. They are based on the neuromuscular coordination of the large muscle groups. According to Payne, Isaacs (2008) motor skills entail the combined physical activity of holding the body, coordinating the upper and lower limbs, rhythmic movements, and so forth. This enables various types of locomotion (walking, running, jumping, swimming) and nonlocomotion (sitting, pulling etc.). When performing gross-motor-skill activities, the child is exposed to stimuli that act on all the senses. The specific sensory control of gross motor skills is:

- vestibular (perception of the movements and position of the body and its parts via the sensors of vestibular apparatus in the inner ear),
- proprioceptive (perception of body movements and positions through receptors in the muscles and joints).

When a child performing movements experiences sensory perceptions, the brain processes that information and tells the body how to react. The signals are sent to the relevant muscles and the body begins to move. Sensory feedback is involved in the process of motor learning. Gross motor skills cannot be developed without frequent training and repetition. The skills that make up the gross-motor-skill group are considered to be the basis of higher-level skills associated with learning and acting.

Fine motor skills are movements requiring fine muscle coordination and the activation of small muscle groups. Development of the fine motor skills leads to finer movement coordination. It improves feedback control and movement. Fine motor skills are used in self-care, schoolwork, and artistic activities, as well as in physical education and sport. Fine motor skills often combine with gross motor skills to produce the overall action. Doing up buttons and zips, using cutlery, and reading all require coordination of the small muscles used in fine motor skills, known as distal muscles. They are linked to the proximal muscles, the largest muscles in the shoulders, torso, and thighs used to hold the body. According to Opatřilová (2008) fine motor skills consist of: a) graphomotor skills — the movements used when writing, b) speech motor skills — movement of the speech organs, c) facial expressions — movements of the face, d) oro-motor skills — movements of the mouth, e) visual motor skills — visual feedback control.

Motor responses to stimuli from the external environment and the human organism develop through nerve activity. Neuromotor skills involve both conditioned and unconditioned reflexes, and voluntary (conscious, controlled), and involuntary movements (automatic) regardless of the stimulus eliciting them. Movement coordination is understood as the organization and coordina-

tion of complex processes and relations within the neuromuscular system. Impaired coordination in children with attention deficit and hyperactivity disorder manifests itself in:

- movements being incorrectly performed,
- the inability to harmoniously combine the elements of a movement,
- less precise movements accompanied by unnecessary movements and high energy expenditure (Adamírová, 2006).

Sensomotor skills relate to the mental regulation of a person's actions through a system involving receptors and sensomotor perceptions. Stimuli are perceived by receptors (motion, optic, auditory, olfactory, position, tactile, taste etc.) and transmitted by the nervous system to the body, triggering movements. Sensomotor skills also act as a signaling system, connecting the inner world with the external one and the needs of the individual.

Social motor skills have developed as part of human existence in social groups and through various aspects and processes of social life. They include a person's movements, behaviors, actions, and reactions within the family and among peers at school.

In a narrow sense **psychomotor skills** include all a person's physical skills combined and are a manifestation of their mental functions and mental state. Szabová (2001) has suggested that psychomotor skills can only be viewed as an integral whole. Feelings, thoughts, perceptions, and exercise are mutually interconnected and impact on each other. Children's psychomotor displays can be interpreted as psychomotor adaptation (e.g., body movements adapting to the temporal and spatial conditions). When engaging in physical exercise, children with ADHD form a relationship with themselves and their environment. Exercise is a means and pathway to knowledge and learning. As part of psychomotor development, children compete physical tasks that require them to resolve a situation by understanding the context. Motor skills can therefore be seen as a goal-directed psychomotor system.

The aim of the work was to analyse the signs and specific manifestations of motor skills of children with ADHD.

Results

The theoretical contexts document a systematic approach to determining the specific nature of motor skills and motor learning in children with attention deficit and hyperactivity disorder. Analyzing a range of different methodological approaches we identify the specific nature of motor ability and how it manifests in children with ADHD.

Specific nature of motor skills in children with ADHD

Gross motor skills in children with ADHD

Children with ADHD may experience unpleasant and confusing sensory perceptions when moving, which are the result of differences in the perception and processing of sensory stimuli. They lose interest in exercise, perform fewer exercises, and work less hard at improving their motor skills. Gross motor skills require adequate strength and perseverance skills. Children with ADHD have low muscle tone — *hypotonia*. Floppy muscles and loose joints affect the ability to maintain a stable position during exercise. Children with attention deficit and hyperactivity disorder are less aware of their movements and so find it harder to learn new and unfamiliar movements and skills. Children spend less time in active play and this affects healthy lifestyles and obesity prevention.

Proprioceptive perception of body movements is another problem in ADHD. Generally proprioceptive perception is unconscious and mediated by sensory receptors in the muscles and joints. It enables the person to perform accurate movements (even with closed eyes) and to automatically and unconsciously adjust body position. Children with impaired body-movement perception have to concentrate on movements that are performed automatically under normal circumstances. They do not perform movements smoothly or quickly. When compared with the movements of children without ADHD, they appear uncoordinated and clumsy (Kurtz, 2015).

Planning movement execution is the ability to imagine, plan, and perform non-automatic movements and operate the muscular system. In planning deliberate movements, children with ADHD must have a clear idea of how the movement is performed. Accurate vestibular and proprioceptive feedback is required for movement execution. The ability to quickly and automatically correct and adjust movements in time and space is also important. Children who have problems planning movements are *dyspraxic*. Children with dyspraxia learn to move slowly and find it harder to use these movements in new situations. Failure frequently leads to a loss of interest and the child starts to avoid difficult activities. Paradoxically dyspraxic children are sometimes very good at coordinating difficult movements, once they have learnt them and stored them in their memory.

The ability to mutually coordinate both sides of the body when performing movements is known as *bilateral integration*. This is *laterality* (from Latin, *latus* = side), understood as developmental, physiological asymmetry — asymmetry in the central balance of the organism. It is the dominance of one side of the body over the other (Měkota, Novosad, 2005). Laterality consists of

both lateral asymmetry (differences in the anatomic and morphological structure of paired organs), lateral preference (differences in the co-functioning of paired organs resulting from the neuropsychological regulation of leading and co-functioning roles), and lateral dominance (differences in the neurophysiological areas regulating the activities of the paired organs). Bilateral integration is involved in cognitive awareness, of the right and left sides, for example. Kurtz (2015) has stated that children with ADHD often switch upper-limb use when performing activities. The inability to identify a dominant side is connected to problems in the vestibular processing of stimuli.

A further problem concerns coordination of the upper and lower halves of the body. This has to be taken into consideration when selecting an appropriate sport for children with ADHD. Volleyball and basketball are difficult in terms of coordination because both halves of the body have to work together. Ice hockey is hard for children with ADHD because they have to learn to skate and use a hockey stick at the same time. Ideal sports for children with ADHD are football, skiing, or cycling, as they involve less concentrated coordination of the upper and lower halves of the body (O'Dell, Cook, 2004).

Kurtz (2015) described the symptoms of gross-motor-skill problems in children with ADHD as:

- greater difficulty learning new skills and tiring more quickly than other children,
- problems using both sides of the body together (e.g. when jumping over a skipping rope),
 - avoidance of difficult physical activities, games, sports,
 - stumbling, falling, and lack of coordination when running, walking, and delayed achievement of developmental milestones relating to motor skills,
 - stronger emotional reactions to ordinary experiences of physical activity, both positive and negative.

Fine motor skills in children with ADHD

Children with ADHD have problems distinguishing fine hand movements from larger body movements. Handling objects requires precision and a stable position so the child can better concentrate on the actions. Fine motor skills are quicker, smoother, and more automatic. They affect actions relating to school work. For example, reading requires the coordination of the eye-movement muscles. Children have to learn to visually follow the teacher, look at the board, and then back down at their notebooks. Speaking in a clear and coordinated manner requires precise use of the speech organ muscles. Fine mo-

tor skills involve the “eye and hand”. The eye and hand coordination involved in fine movements relies on visual and proprioceptive information regarding the shape, size, surface, and mass of an object. This then decides the force with which we grasp something. Visual, tactile, and proprioceptive feedback enable us to handle an object. The timing of the movement is also important, for example in hitting and catching a ball. In their research, Vickers, Rodrigues and Brown (2002) found that children with ADHD had problems following a fast-moving ball.

Signs of fine-motor-skill problems in children with ADHD:

- avoids activities involving fine motor skills, dependent on adults for self-care,
- holds a pen or pair of scissors oddly, writing problems, frequently drops objects,
- incorrect articulation,
- delayed achievement of developmental milestones (Kurtz, 2015).

Neuromotor skills in children with ADHD

Children with attention deficit and hyperactivity disorder have problems identifying and processing information from vestibular receptors and proprioceptors in the muscles and joints, as well as reacting to them. Neuromotor skills are closely linked to spatial balance and orientation. They concern the ability to precisely judge the position of the body and changes to its position when performing movements. This includes being aware of the time parameters and checking the required spatial conditions. The level of spatial orientation and movement adaptation is affected by general intelligence and memory. With children who have ADHD, it is important to stimulate and concentrate their attention on the temporal and spatial dimensions. Activities should focus on the children’s perceptions of their position and movements, the direction of movement by other people and objects, and orientation in space.

Sensomotor skills in children with ADHD

Through sensory perception, sensory integration (integration of the sensory systems) and sensory modulation (selective perception of sensory stimuli) we obtain a full image of the complex environment around us. Children with specific learning problems often have difficulty integrating sensory information. Emotional behaviors, stress, and

tiredness lead to sensory perceptions being inadequately received by the organism. The information entering the brain is not assessed correctly. The child has to concentrate more on each part of the situation, and that is very demanding. Eye-movement integration entails connecting the visual image to the fine and gross motor skills that generate the right motor response to the environment. Children with ADHD have problems linking the image with the movement, and adjusting them appropriately. Children with insufficiently developed tactile differentiation skills find coordinating movement difficult. Their brains interpret ordinary tactile stimuli as unpleasant and even dangerous. In physical games an unexpected tactile stimulus (the ball, an obstacle, fellow player, etc.) may provoke a brief emotional reaction that triggers stress. Many children with ADHD exhibit deficits in processing aural stimuli, despite their hearing being within the norm. Unexpected sounds can disturb them, and they may react with fear. By contrast, they do not become aware of other aural stimuli (the teacher's instructions) (Kurtz, 2015).

Signs of a sensory-perception deficit:

- not reacting appropriately to pain or extreme temperature, being unable to identify where they have been touched,
- feeling the need to touch things, which can complicate games involving equipment,
- being unable to maintain balance during activities, being insufficiently aware of their own body,
- handling equipment clumsily,
- longing for intense physical activity, wanting to run, jump, bump into things without regard for safety.

Signs of being overperceptive to sensory stimuli:

- avoiding games they could get dirty in,
- frequently being distracted by ordinary noises during physical activity, overreacting to noise, the sound of the whistle,
- not being keen on fast games, preferring sedentary activities,
- disliking performing complex movements, having problems with upside-down positions (e.g., putting their head down) (Kurtz, 2015).

Social motor skills in children with ADHD

Physical exercise can be used to develop the personality of a child with ADHD. The social side is integral to teaching movement. The family, teacher, childcare worker, and trainer have the most influence. Activities performed by those they admire and attempt to imitate, such as successful sportsplayers, are also important. Some physical activities are solo events but most are performed in pairs

or groups. It is through these activities that they naturally develop their personality, social skills, and relationships. Children with ADHD find competitive and performance-related tasks difficult because of psychomotor restlessness and physical clumsiness. They are forever moving but do not concentrate on their movements. The naturalness, spontaneity, and fun of physical exercise makes it ideal for such children to abreact, become meaningfully engaged, unwind, and feel useful and successful (Szabová, 2001). It can be used to overcome fear, for example, or to stimulate feelings of fulfillment. When exercising children feel motivated and encouraged, and this is important to them developing a good relationship with exercise. It also gives them an opportunity to transform any negative feelings that could hinder motor-skill development. Physical exercise has an effect on the individual's relationship with the team, and it helps individuals to cope with social phobias. It helps them to develop appropriate communication, and positively supports self-esteem and self-realization. It enhances the ability of children with ADHD to cope with the symptoms of stress.

Psychomotor skills in children with ADHD

The nature of perception in children with ADHD sets out the conditions for psychomotor development. The different domains of movement are performed simultaneously, and overlap and influence each other. It is therefore important for children with ADHD to attend psychomotor interventions. Targeted therapeutic stimulation develops and corrects development deficits, and delayed or under-stimulated areas of children's mental and motor skills. Change can be achieved through repeated, systematic, and high-quality activation. Stimulation can target one area or multiple, interconnected psychomotor areas, or it can be global. Psychomotor physical exercises significantly stimulate sensory development, or kinesthetic perception (Boržíková, 2018).

Conclusion

In teaching or therapeutic processes of children with ADHD, an effort is made to positively influence the child's personality through exercise and help him or her cope optimally in everyday psychosocial contexts.

Therapeutic exercise interventions for children with ADHD generally take the form of targeted stimulation programs. This may consist of working individually with the child, with parent participation or in groups of children who have the same disorder and developmental level. The difficulty is gradually in-

creased, and new stimuli and other ways of working, interesting modifications, variations, and combination of physical activities can be introduced. The method adopted by the teacher, teaching assistant, or therapist should involve appropriately demanding physical activities: locomotion, nonlocomotion, manipulation (of various tools, equipment in different settings), psychomotor exercises, undemanding physical games and sports, as well as experiential and adventure games. Teachers should be familiar with methods for using special resources in the physical education of pupils with ADHD that target the development of fine and gross motor skills. They should use creative, nontraditional, motivating resources and forms of physical education. It is important the activities have simultaneous cognitive and affective components. It is good to give the child an opportunity to test their potential in unusual and entertaining ways.

We believe that these theoretical contexts, research findings, and practical implications represent a systemic approach to interpreting the concept of motor skills and motor learning in children with attention deficit and hyperactivity.

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