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The Sensory Integration through Motor Movement in Occupational Therapy to Change the Behavior of ADHD Children

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ABSTRACT : *Attention-Deficit-Hyperactivity Disorder (ADHD) is most diagnosed in children and is characterized by difficulties in maintaining attention, focus, and self-control. Standard treatments for ADHD typically include medication and behavioral therapy. Additionally, there is evidence supporting the effectiveness of occupational therapy, specifically using Sensory Integration (SI) techniques. SI focuses on the central nervous system's processing of sensory information from the body and the environment, facilitating appropriate responses to various stimuli. This fundamental skill is crucial for learning and kinesthetic awareness, and it can lead to brain plasticity at the neuronal level.The practice of motor movements is a valuable tool in this context, as it helps establish neural circuitry connections in the brain and spinal cord that are essential for learning. Children who engage in structured practice of motor skills can develop good motor coordination and enhance the efficiency of neuromuscular coordination. This improvement leads to positive characteristics such as self-confidence, patience, and social adaptability. These positive traits are supported by a sense of competence and self-assurance, which are indicative of good self-control.Therefore, movement can contribute to personality development and behavioral change in a rational and evidence-based manner. Sensory integration through motor activities can be organized as an occupational therapy approach to improve behavioral outcomes in children with ADHD.*

KEYWORDS *-Sensory Integration, Motor Movement, Behavioral Changes, ADHD Children*

I. INTRODUCTION

Children are invaluable resources and represent a nation's future, making it essential to provide them with appropriate care and developmental support at every stage. This includes fostering intellectual, physical, and psychological growth to ensure they mature into well-rounded adults. According to demographic statistics, the birth rate in Thailand has increased by 10% per 1,000 people (Ministry of Labor, National Statistical Office of Thailand, 2023). Although the birth rate is not significantly high, there is a global shift towards valuing quality over quantity in population growth. In Thailand, 16% of the population comprises school-aged children between 0-12 years old, a critical period for learning life skills and cognitive development due to rapid brain

growth (Benjarat, 2018; Thumthong, 2021). If obstacles to development occur during this period, children may experience age-inappropriate development, leading to behaviors that are difficult to change, particularly in mental health and learning. Among these challenges, many children exhibit symptoms of Attention-Deficit-Hyperactivity Disorder (ADHD) and intellectual disabilities.

ADHD is a neurodevelopmental disorder that typically emerges before the age of 12. It is the most diagnosed condition in children, characterized by difficulties in maintaining attention, focus, self-regulation, and task management (Ward S. et al., 2015). International studies estimate the global prevalence of ADHD among children and adolescents to be around 3-5% (Wiener JM., 2007), with a rising trend (Ayano et al., 2023). In Thailand, a study of elementary school children in Bangkok found an ADHD prevalence of 5.01%, indicating that in an average classroom of 40-50 students, there may be approximately two children with ADHD (Visanuyothin et al., 2013). This prevalence has been increasing annually, with data confirming 116 cases of children under 15 years old receiving treatment for ADHD at Prachonchai Hospital's ADHD and Child Development Clinic between 2020-2021, highlighting the growing concern (PatchimaLormprakhon, 2022).

Medical treatment for ADHD commonly involves medication and behavioral therapy. However, other interventions, such as nutritional therapy, psychological biofeedback, and occupational therapy, have also been researched and shown to provide effective and continuous treatment outcomes (Pediatrics, 2001). Occupational therapy for ADHD often incorporates techniques like Sensory Integration (SI) (Schaaf et al., 2018) and training in executive functions (EF) (Phelan, 2012). These approaches focus on the central nervous system's role in processing sensory information from the body and environment, responding to various stimuli, and serving as foundational skills necessary for learning. This process involves sensory registration, modulation, integration, discrimination, and adaptation to stimuli, with a focus on brain structures such as the brainstem, cerebrum, limbic system, and cerebral cortex (Dunn, W., & Bennett, D., 2002). These brain regions coordinate motor control, attention, emotion, memory, arousal levels, autonomic functions, and higher cognitive functions.

Kinesthetic sense, the awareness of body movement and position, is facilitated by sensory input from muscles, tendons, and joints, enhancing the brain's learning response beyond sensory inputs like vision, hearing, smell, and touch. Practicing motor skills is particularly effective, as it helps develop neural circuits in the brain and spinal cord, critical for learning (Hoffman et al., 2005). Structured practice, progressing from simple to complex movements and from slow to fast, enables children to develop good motor coordination and discrimination skills, leading to accurate and confident physical responses. This ability to distinguish and process information efficiently reduces cognitive load, promoting concentration, self-confidence, and self-control in all situations. These improvements prevent stress and confusion in the brain, which are major obstacles to learning (Supaviboon&Krabuanrat, 2021). Consequently, children develop positive traits such as self-confidence, patience, and social skills, supported by a sense of competence and self-assurance, indicative of good self-control.

Thus, integrating sensory and motor activities in occupational therapy can significantly enhance learning, improve neuromuscular coordination, and promote personality development and behavior modification. Even children with ADHD can benefit from specialized movement-based occupational therapy (Ayres, 1964). The author recognizes the importance of sensory-motor integration in occupational therapy for behavior modification in children with ADHD. This work aims to compile and synthesize methods for systematic movement-based interventions to provide an alternative treatment for ADHD, supporting continuous development in learning, physical, and psychological domains, comparable to their peers.

II. Differences in brain processing in normal children and ADHD children affecting behavioral expression.

Attention-Deficit-Hyperactivity Disorder (ADHD) is a brain functional disorder with three main behavioral disorders: 1) Inattention, 2) Hyperactive, and 3) Impulsivity, which is more than the normal behavior of a child at the same level of development and causes problems in daily life or social integration. (American Psychiatric Association, 2022)

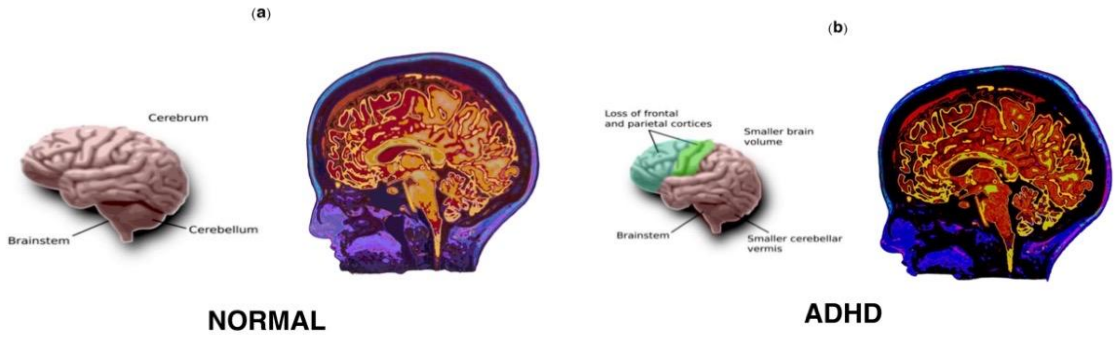
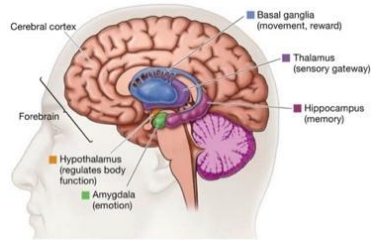
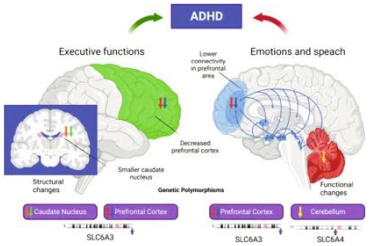


Fig. 1, Shows the differences between (a) a normal child's brain and (b) ADHD child's brain. (Barua, et.al., 2022)

The image shows that the brain of an ADHD child is biologically different from that of a normal child who is not focused. It can be divided into three parts, as shown in the table below.

Difference.	ADHD Brain Imagery	Description
Part 1. The structure of the brain.	 	Children with ADHD have the size of the amygdala and hippocampus parts of the brain, which are smaller than the normal child's brain. The amygdala parts are emotional parts such as fear, anger, anxiety, and the hippocampus are brain parts that are related to memory, short-livedness and long-term life. And some parts of ADHD children's brains are also found to grow fully at a slower rate (about 1-3 years).

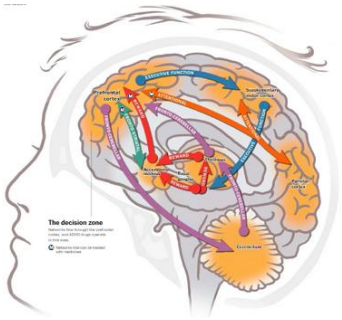
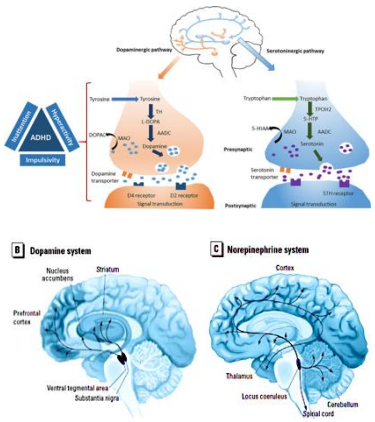
Part 2. The function of the brain.		Children with ADHD have reduced blood circulation to the prefrontal cortex, which makes this part of the brain less functional, which is important for thinking, planning, resolving problems, making decisions, and concentrating, as well as emotional control, restraining, waiting, and emotional expressions such as fear, anger, and rage.
Part 3. Chemicals in the brain.		The brain can communicate between the cells by having a neurotransmitter or chemical in the brain that acts as a messenger between cells. In ADHD children, there is a disorder or imbalance of the chemicals called dopamine and norepinephrine, which in the ADHD group may have too few of these two neurotropic agents due to insufficient or inefficient receptors.

Table 1:Shows 3 parts differences in the biological aspects of the ADHD brain. (Yadav, et.al., 2021)

The functioning of the brain and behavior are closely related. There is little data from the research that found that short-focused children (ADHD) have structures of the central nervous system, the hypothalamus, and the amygdala. The disturbance that causes anxiety behavior remains unusual. Because the abnormal structures in the brain are related to the responses of the autonomous Nervous System, resulting in physiological changes. The function of the hypothalamus is considered to be an intermediary between the automatic neurons that receive information from the Amygdala, which is responsible for exchanging information with the frontal cortex. The cerebral cortex, the amalgamates portion, responds not only to past reactions, but also to emotional and emotional experiences. (Bear, Connors,& Paradiso, 2007)Children with self-control difficulties have difficulty learning and coping with their own behavior, which leads to unregulated learning development. Dr.A. Jean Ayres, an American activist therapist and academic psychologist, has been developing the theory of brain balance since 1980.1960, from the Brain Research Institute of the University of California, and proposed the concept of sensory integration of the brain, which is the ability to combine sensory reception, organize information to generate learning, and respond to proper behavior effectively. (Ayres, 1972)

III. The Sensory Integration with the Behavioral Change of ADHD Children

Sensory integration is the process of the nervous system dealing with sensory information received from the body, including the environment around it, for use in life. And of course, such a process occurs in the central nervous system, which consists of a huge number of neurons, spinal nerves, and the brain. (Ayres, 1966, 1967, 1972). In the past, researchers and doctors have pointed out that children with ADHD are often affected

by deficiencies in sensory processing and sensory modulation dysfunction in certain areas of the body (Cermak, 1988; Mangeot et al., 2001; Parush, Sohmer, Steinberg, &Kaitz, 1997). Sensory processing refers to how the central nervous system and the extremities handle incoming information, as well as stimulation leveling. Integration and handling of stimulation (Miller & Lane, 2000). Such sensor modulation is regarded as part of a method of processing sensory information (the sensory process). For this reason, researchers have attempted to use both child behavioral and child-sensory response patterns to measure children's behavior.

Background research has found that the child's ADHD test process is based on physiological and behavioral measurements, such as a physiological test using the Somatosensory Evoked Potential (SEP), which is an electrical test of the brain resulting from the stimulation of contact. By integrating SEP recordings at different levels of the contact pathway, it is possible to evaluate the passage of walls from the outer circle up to the cerebral membrane (Parush et al., 1997) and measure the changes in the electrical conduction of the skin, including the change in the stage of the electrodermal reaction (Electrodermal Reactivity: EDR) (Mangeot et al., 2001), which has shown significantly that children with ADHD have differences in neurological reactions when compared to children's behavior, which generally increases the exposure of children to ADHD behaviors like (Ayres, 1964; Bauer, 1977; Lightsey, 1993). Visual, auditory, and taste. (Papadopoulos & Staley, 1997) Research indicates that ADHD children have disabilities in the vestibular system and somatosensory function, resulting in unrighteous sensory processing as well as problems in coordination and motor planning. (Blondis, 1999; Kadesjo&Gillberg, 1998) Therefore, proprioceptive sense is very important in translating the senses of body position to motion. Because of the functioning of the muscle system, body awareness, which is the basis of motion control and motion planning, enables humans to effectively control their bodily movements, walk smoothly, or run fast, resulting in emotional security and always being confident in their own movements. Of course, there is a relationship that can lead to behavioral change if therapeutic activities are carried out in the form of regular movement.

Children need to acquire a diverse range of movement skills during early childhood, focusing on fundamental movements essential for their development. These include basic movements such as standing up, walking to avoid hazards (like dodging), bending, rolling, and foundational sports skills like running, jumping, and throwing. These activities all involve the processing of sensory information.The proprioceptive sense, or the awareness of body movement and position, is enhanced through practice, as sensory information from muscles and joints is transmitted to the brain. This process stimulates and accelerates the development of the brain's perceptual and cognitive responses (Krabuanrat, 2009, 2014, 2016). Regular physical activity not only influences brain structure but also impacts behavior, as illustrated in Figure 2.

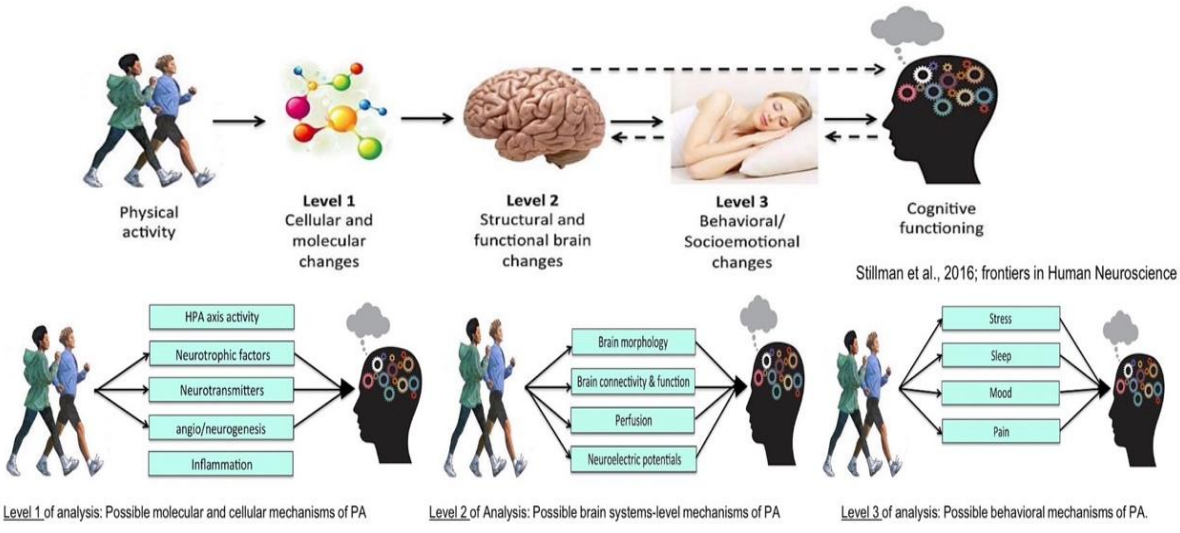


Fig. 2, Shows the direction of physical movement activity that affects brain development and behavior.

(Stillman et.al., 2016)

Active participation in physical activities, such as play that involves body movement, is crucial for children's development. It not only fosters a positive attitude towards various aspects of life but also contributes to mental well-being. According to a survey conducted by the Ministry of Education in Thailand on preschool children, those who engage in regular physical activity are more likely to exhibit positive traits such as self-confidence, patience, sociability, and the ability to interact with others. Children observed to be confident often engage in more physical activities, freely running around and playing with peers at school. Regular practice of physical activities helps children develop confidence, which persists throughout their lives. This confidence is supported by a sense of competence and self-assuredness. Through play and interaction with other children, they learn to follow rules, exercise self-control, and communicate effectively to collaborate and work together. By around ages 5-6, many children learn to take on leadership roles or fulfill specific roles within a group.Play, especially structured play with rules, offers opportunities to stimulate social development. Physical play also serves as means to relieve stress and rejuvenate the body (Japan Sport Association, 2021).

IV. Treatment of ADHD with Occupational activity through the mechanism of movement.

Occupation therapy is defined as an action involving the abilities of a person with physical, mental, learning, or developmental disabilities. The evaluation process promotes prevention and revitalization of activities to enable a person to live his or her life to the fullest potential by introducing appropriate activities, methods, and equipment as a method of therapy. The therapeutic activities are identified in several categories and are mainly focused on mental tasks, strength, balance, coordination, and social interaction. (East End Occupational Therapy in Sayville) The theory used by activists in the treatment of children with disabilities is the theory of sensory integration. This theory focuses on the integration of the three main touch nervous systems: tactile sense, vestibular sense, and proprioceptive sense. (Chinchai, 2017)

Table 2:Occupation activities related to movement patterns. (Ayres,1967)

Sensory receptors	**Guidelines for organizing Occupation activities.**
Tactile Sense	- Moving in a large container of plastic balls or ball pit - Crawling or burrowing under a textured light ball - Playing with a massager or vibrating toy - Identifying objects hidden in a container using only touch (stereognosis)
Vestibular Sense	- The use of suspended equipment allows for multidirectional movement controlled by the clinical - Challenged at the just-right level by asking the clinical to change the direction or speed of movement or to move intime to an auditory cue (e.g., hand clap or metronome).
Proprioceptive Sense	- Pushing, Pulling, and Carrying - Oral Motor Activity

	- Movement Activity

Physical activity, motor movement, and exercise all have positive effects on the functioning of children with ADHD. (Vysniauske et al., 2016; Stillman et al., 2016; Richard A. et al., 2017). In line with Dr. Krabuanrat (2009) and his predecessor (Wongupparaj, Kumari, & Morris, 2015), which stated that a planned and systematic training pattern (Planning & Designing Training) would play an important role in stimulating development, brain cells, and frontal cortex functions, as well as motor control, in planning and managing movement, Of course, the planning process to develop learning skills, such as movement mechanisms, would have to take place systematically, step by step, as shown in Figure 3.

Motor skill learning is a process of functioning of the nervous and muscular systems that cannot be seen with the eye but can be observed by the progress or changes that arise from the practice of each child's skills. It can also be seen by synthesizing the individual's specific movement relationships. Provision of a variety of physical movement activities through conditional play. Play is considered the basis of the neurosensory integration of the brain (Neumann, 1971; Bateson, 2000; Parham et al., 2011) and is a form of therapeutic activity. Therefore, teachers need to understand what movements are associated with individual physical movements and how those movements can be developed qualitatively. (Japan Sport Association, 2021)

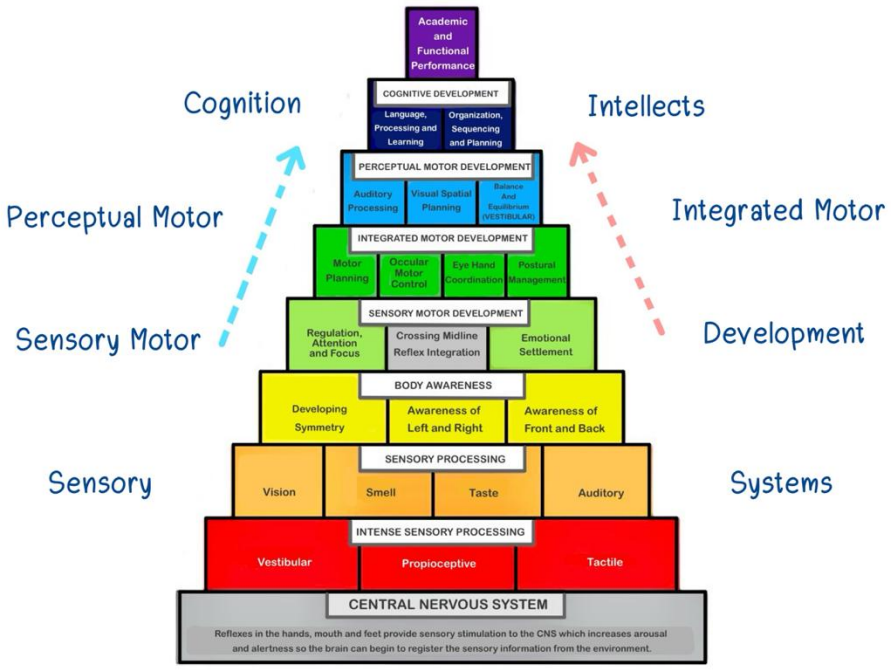
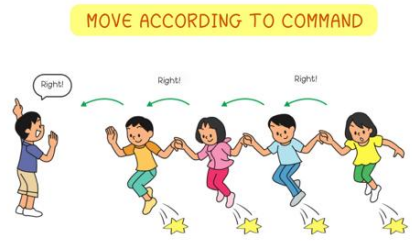
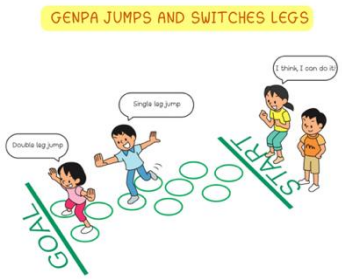
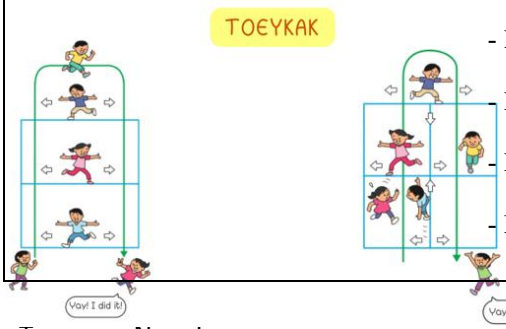
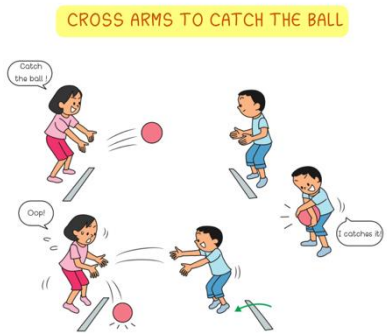
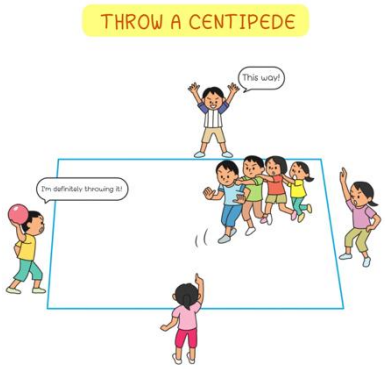


Fig. 3, The Hemispheres pyramid shows the process of development and learning. (Horak, 1991)

These activities are designed to SI input through playful movement, helping children enhance various physical, sensory, and social skills as part of occupational therapy interventions.

Table 3. Examples of Sensory Integration Through Movement Mechanisms Using Play in Occupational Therapy (Japan Sport Association, 2021)

Occupational Therapy	Classification of Fundamental Movement			Intense Sensory Processing
	Locomotor Skills	**Stability Skills**	**Manipulation Skills**	
Move According to Command 	- Jumping - Sliding	- Landing - Balancing	-	- Vestibular sense - Proprioceptive Sense
Gen-Pa Jump and Switches legs 	- Jumping	- Balancing - Landing - Stretching	-	- Vestibular sense - Proprioceptive Sense
Chasing Spiders 	- Crawling - Crawling (Face up)	- Balancing - Turning - Twisting - Flexing - Stretching	-	- Tactile Sense - Vestibular sense - Proprioceptive Sense
Toey - Kak 	- Walking - Running - Hopping - Bounding - Leaping	- Balancing - Landing - Twisting - Stretching	-	- Tactile Sense - Vestibular sense - Proprioceptive Sense

	- Sliding			
Cross arms to catch the ball 	-	- Balancing - Stretching - Bracing	- Throwing - Catching	- Tactile Sense - Vestibular sense - Proprioceptive Sense
Throw a centipede. 	- Walking - Running - Sliding	- Balancing - Turning - Twisting - Flexing - Extending - Stretching	- Throwing - Catching - Pushing - Pulling - Carrying	- Tactile Sense - Vestibular sense - Proprioceptive Sense
Throw The King 	- Walking - Running - Sliding	- Balancing - Turning - Twisting - Stretching - Rotation	- Throwing - Catching - Pushing - Carrying	- Tactile Sense - Vestibular sense - Proprioceptive Sense

Group Jump Rope 	- Jumping - Galloping - Sliding	- Balancing - Landing - Twisting - Stretching	- Collecting - Carrying	- Tactile Sense - Vestibular sense - Proprioceptive Sense

From the table, the combination of different movements is considered a suitable pattern for children with ADHD because the basis of their symptoms is that they do not like to do anything repeated. Not so much. Using patterns of movement activity that children have never experienced before. For example, instead of running a catch, we can tell children to pretend to be rabbits. By doing so, children will experience the movement of jumping. Motion-cognitive intelligence can increase the variety of body movements. On the other hand, increasing the pattern using an adapter is a key word by adding the adapter of movement, such as going forward, slower, higher, quieter, etc. Then, if you notice the development of better movements, adjusting patterns is more complicated when mixing movements or devices. For instance, by bringing the ball into play with mixed movements and then throwing hot throws, the child will experience a variety of new movements that are balanced.

V. Discussion

Children with Attention Deficit Hyperactivity Disorder (ADHD) often face challenges in learning, self-regulation, and daily behavioral control. Sensory Integration (SI) is an approach used in Occupational Therapy (OT) to assist these children in improving their ability to regulate behaviors and sensory processing. The therapeutic approach involves engaging ADHD children in activities that promote sensory integration through play and movement mechanisms. This approach aligns with findings from a meta-analysis that studied the efficacy of sensory integration interventions in treating children with ADHD, emphasizing the role of physical movement and participation in various activities. The study concluded that sensory integration significantly enhances the functional abilities and participation levels of children with ADHD (Andelin, L., Reynolds, S., & Schoen, S., 2021).

Furthermore, numerous studies have demonstrated that sensory integration therapy can effectively reduce behavioral issues and improve self-regulation in children with ADHD (Miller et al., 2007; Schaaf et al., 2014). This is consistent with the findings of Daley, David, and Chris P. (Daley, D., & Hollis, C. P., 2021), who reported that sensory integration therapy effectively manages behavior and emotions in children with ADHD. Their study compared the efficacy of pharmacological and non-pharmacological treatments, emphasizing the importance of individualized approaches tailored to the specific needs of each child. The role of sensory integration in improving daily living skills among children with mental health issues, including ADHD, was also highlighted (Swarbrick, M., & Noyes, S., 2018).

The collective research findings suggest that sensory integration therapy significantly enhances emotional and behavioral regulation in children with ADHD, fostering social development and learning abilities. Specifically, it improves the capacity to perceive and process sensory information, enabling better adaptation to various situations (Case-Smith et al., 2015). These insights underscore the importance of sensory integration as a critical component in the therapeutic regimen for children with ADHD, helping to improve behavior and learning in a reasoned and structured manner. Recent research demonstrates the effectiveness of this therapy in aiding children to self-regulate and appropriately adjust to different situations in their daily lives.

VI. Conclusion

Children with ADHD can be treated with activity through play-based movement mechanisms. This therapy is not a free-play activity but a conditional activity that determines the child's perception of movement. Even when children have a mental disorder, there are attempts to resolve problems conditionally or to find solutions to physical movements that can be achieved successfully in each of the activities that are integrated into the condition. The receptor inhabitants transmit information to the brain to perceive or translate the meaning. This is a learning stimulant that will lead to the reorganization of the nervous system. When the body repeats the activity, the brain cells are transferred, processing information accurately and much faster. When the brain is effectively managed, this leads to effective behavioral changes, including self-control, which can lead to age-based behavioral changes.

The conclusion is that sensory integration through motor movement is a guideline for organizing an occupational therapy model to change behavior for ADHD children rationally and effectively.

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