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Chapter 34
Neurodevelopmental Therapy: Sensory Integration and Vestibular Stimulation Intervention in Mentally Retarded Children

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Mentally retarded children's development is influenced by their participation in programs containing a sensory integrative intervention, such as the vestibular stimulation and neurodevelopmental treatment.

Abstract Mental retardation is a disability characterized by significant limitations both in intellectual functioning and in adaptive behavior as expressed in conceptual, social, and practical adaptive skills. Sensory integration is the brain's organization of sensory input.

The degree of sensory integration and postural control dysfunctions in mentally retarded children has great variations. The function of learning depends on the child's ability to make use of environmental sensory information and to integrate this information to perform purposeful behaviors.

The use of neurodevelopmental treatment emphasizes the children's active participation in goal-oriented activities. The sensory integration frame of reference is critical to treating deficits in the nervous system before other issues can be addressed.

Keywords Mental retardation • Neurodevelopmental treatment • Sensory integration • Vestibular stimulation

Definitions and Background

Children's Normal Motor Development

Normal development of movement and function is essential for the child's development of motor control and learning abilities. Motor learning develops in stages during the child's general development. Movement and posture are learned in sensory states for the child in a suitable environment.

Physical activity is necessary for motor development. Therefore, the child should move actively to gain basic motor skills such as turning, sitting, crawling, and walking.

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The *development of postural control* occurs in stages comparable to the child's ability to integrate sensory information.

Between the *ages of 1 and 3 years*, the sense of sight is the dominant source, nessesary for achieving and maintaining the orientation of the upright position. At these ages, the proprioceptive system generates simple and incomplete information. Therefore, training of the somatosensorial system is needed if the child is able to utilize proprioceptive information effectively.

Between the *ages of 4 and 6 years*, somatosensorial and vestibular input's are the dominating sources for effective motor control.

Between the *ages of 7 and 10 years*, response according to those of adults is observed. The fundamental source of postural stability in children and adults is somatosensorial. General movements and reflexes enable voluntary and adaptive motor control. However, postural control develops first and provides the basis for movement whereas well-balances and coordinated movements occur (Martin, 1989).

Mental Retardation

Brain damage during the intrauterine period of life results in severe neurologic dysfunctions, such as mental retardation and cerebral palsy. Individuals have mild, moderate, severe, or profound retardation, based on intellectual impairments (American Psychiatric Association, 1994; World Health Organization, 2008).

Mental retardation is a disability characterized by significant limitations in intellectual functioning and adaptive behavior as expressed in conceptual, social, and practical adaptive skills, which originates before the age of 18 (American Association on Intellectual and Developmental Disabilities [AAIDD], 2008). Adaptive behavior signifies the quality of daily performance in dealing with environmental needs. Ten adaptive areas are considered critical to the diagnosis of mental retardation: communication, self-care, home living, social skills, community use, self-direction, health and safety, functional academics, leisure, and work (Lambert et al., 1993).

The motor control in these children commonly shows (1) joint and muscular *hypotonicity*; (2) a decrease in deep tendon and maintenance of primitive *reflexes*; (3) delays in *motor development*, such as slow reaction time, nonequilibrium reactions, and laterality; and (4) deficits in *visual motor control*, such as deficits in eye-hand coordination.

Sensory Integration Theory

The neurodevelopmental treatment uses automatic and voluntary components of postural control and skill acquisition as treatment mediator (Shumway-Cook and Woollacott 1985; Uyanik et al., 2003).

Sensory integration is "*the organization of sensory input for use*" (Ayres, 1979), which signifies a neurologic process. This enables spatial-temporal integration and use of the sensory information that children get from their body and environment. This is

the prerequisite for children to be able to plan and design organized motor behaviors. According to the sensory integration theory, mild and moderate problems in learning are related to a defective motor coordination and a weak sensory process (Ayres, 1972; Scheerer, 1997). Moreover, sensory integration is significantly related to the development of hearing and language skills in addition to motor coordination (Ayres, 1979).

Sensory integration theory is based on the view that *neural plasticity* and sensory integration occur as long as the brain functions integrate with the hierarchically related systems. Adaptive motor response is the most significant parameter of sensory integration. "An adaptive response is a purposeful, goal directed response to a sensory experience" (Ayres, 1979).

A child's growth and development is dependent of the development of the tactile, vestibular, and proprioceptive systems (Williamson and Anzalone, 2001):

- The *tactile system* provides information about the environment through the sense of touch. The tactile system constitutes the protective system (informs when touching is harmful) and the discriminative system (informs of the difference between harmful and beneficial touch).
- The *proprioceptive system* receives sensory stimulus from the muscles and joints. Push and pull activities provide maximum stimulus to this system. The proprioceptive system is also important for the development of fine and gross motor muscles. An insufficient proprioceptive system negatively affects motor planning ability.
- The *receptors of the vestibular system* are situated in the inner ear and are related to hearing. The receptors in this system respond both to movement and to gravity. The vestibular system affects balance, eye movements, posture, muscle tone, and attention.

The Role of the Vestibular System in Motor Development

The vestibular system is important in the achievement of normal motor development (Shumway-Cook, 1992). Vestibulo-ocular inputs are significant in eye-hand coordination, which is important for enabling looking at one point in space. Vestibulospinal inputs are significant in maintaining postural stability with visual and somatosensory inputs. Vestibular dysfunction is observed in many developmental disorders, such as deficit in motor coordination and learning disabilities (Ayres, 1972; Shumway-Cook, 1992).

Purpose

Intervention programs including sensory integration and vestibular stimulation are aimed at increasing mentally retarded children's development of perceptual-motor abilities, normal movement patterns, postural reactions, functional balance, gross motor coordination, reflex integration, intellectual functions, language-hearing abilities, and social and emotional functions.

Method

Candidates for the Intervention

Neurodevelopmental programs based on sensory integration or vestibular stimulation are aimed at *children* who are diagnosed with (1) mental retardation, such as Down syndrome; (2) cerebral palsy; (3) delayed development; (4) schizophrenia; (5) immature central nervous system (CNS) disorders, as in some premature infants; (6) a specific learning difficulty; (7) difficulties in speech and receptive language; and (8) behavior problems. These programs are also appropriate for *adults* who have suffered brain damage causing a hemiplegia.

Epidemiology

The prevalence and incidence of mental retardation vary with how it is defined. It is estimated that approximately 89% of children with mental retardation have mild mental retardation, 7% have moderate mental retardation, and 4% have severe to profound mental retardation. In addition, it was reported that the prevalence of mental retardation appears to increase with age up to about the age of 20, with significantly more males than females identified (Biasini et al., 2003).

Settings

Environments that allow personal and active play aimed at stimulating the child's adaptive responses are appropriate for neurodevelopmental interventions. Examples are the snoezelen or controlled multi-sensory stimulation rooms, (Wikipedia, 2008), i.e, specially organized therapeutic rooms situated at occupational therapy units, schools, hospitals, special education settings, inpatient/outpatient, day centers, or at home (Fig. 34.1).

The Role of the Occupational Therapist

The occupational therapist (OT) is responsible for enabling and arranging the environmental stimuli that are used to allow the child to demonstrate appropriate behaviors, and to develop self-care, play, and school skills. During the acquiring process of motor skills, the OT uses oral, supportive, or visual stimuli, as well as positioning of the child and passive movement schema. The child focuses on the goal rather than on the specific motor components of the task. This intervention approach is sequentially performed by qualified professionals (Bumin and Kayihan, 2001; DeGangi et al., 1993; Uyanik et al., 2003).

Fig. 34.1 An example of a snoezelen therapeutic room used for active play.

Clinical Application

The fundamental principle in the intervention using sensory integration is that planned and controlled sensory stimuli with adaptive responses enable improvements in brain function.

Sensory Integration Intervention

The Process

- *Sensory integration* includes *assessments* of the processes of (1) sensory motor integration, (2) adaptation of the individual, (3) effect of the maturation and behavior, and (4) defining the individual's developmental profile. The results of the assessments are analyzed, synthesized, and interrelated to the individual's sensory-perceptual motor behaviors.
- The *goal* of the first stage is to enable the learning of the skills.
- An *individually specialized intervention program* should follow the sensory integration activity training (Ayres, 1979; Bumin and Kayihan, 2001; Lerner, 1985; Scheerer, 1997; Uyanik et al., 2003).

Planning of the intervention should be done according to the following factors:

- The level of function of the child
- The developmental status of sensory integration process of the child
- The primary goals of the intervention
- The intervention methods used
- The frequency of the child's participation in the intervention
- The home programs that are used

The intervention should *follow the order of children's normal development*. Highly controlled behaviors such as running, hopping, bilateral integration, and sequence, writing, and reading, are included with expected improvement in the assimilation and adaptation process of the visual, tactile, proprioceptive, and vestibular stimuli.

The intervention should *depend on intersensory integration process*. The organization of sensory stimuli, which are internalized by the adaptation of the body, and the sensory integration process are the main steps of the intervention.

Home training of child should be provided by the parents and family, including emotional and social development. Here, the child's success depends on the therapist's communication and coordination with the family and with other disciplines while planning the intervention program.

The Content

The appropriate adaptation of the child's *environment* is very important. The following activities are recommended to stimulate the various body sensory systems:

- *Development of gross motor skills* is stimulated by activities such as running, hopping, jumping, and walking in unusual patterns.
- *Body awareness* (enables correct and coordinated movement patterns) is stimulated by activities directed at the vestibular, tactile, and proprioceptive systems.
- The *proprioceptive system* provides information about the movements of the body, and it is stimulated by activities such as climbing, pushing, pulling, carrying heavy objects, and working against resistance and pressure.
- The *tactile system* is stimulated by massage, rolling up in a blanket, having heavy or soft items rolled on top of the child, and deep pressure.
- *Motor planning* (the brain's ability to conceive, organize, and carry out a sequence of unfamiliar actions necessary for learning new skills) is stimulated by following instructions written on cards, ball games, obstacle courses, walking like different animals, and cutting out various shapes on paper.
- *Ocular control* is stimulated by throwing and catching a ball, and by drawing.
- *Bilateral motor coordination* (important for the purposeful use of the hands) is stimulated by task performances that cross the midline of the body.

- *Visual-spatial perception* is stimulated by activities directed toward vestibular and ocular controls, such as recognizing the position of objects in space.
- *Fine motor skills* are stimulated by arrangement of appropriate postural stability; good co-contraction of head, neck, and arm muscles; and good ocular control and performances of activities (Ayres, 1979; Bumin and Kayihan, Lerner, 1985; Scheerer, 1997; 2001; Uyanik et al., 2003).

Vestibular Stimulation Intervention

Content

The structure and position of the vestibular stimulus is important for reaching efficiency. The stimuli may be of an excitatory nature, such as rapid movement, or of an inhibitory nature, such as slow, rhythmic, and passive movement. Rotational movement and linear acceleration-deceleration, turning, and swinging back and forth stimulate all types of receptors. In addition, positioning upside down, lying prone and supine, and sitting activate different parts of the vestibular canals at different degrees. The horizontal position and especially the prone position are more stimulating than the upright position. Shifting between different head positions is necessary for the stimulation of the vestibular receptors (Ayres, 1979; Kelly, 1989).

Types of Intervention

- Linear activities are used to normalize *extensor muscle tone* by increasing stimulation input of the otolith organ. The recommended activities are the following:
  - Bouncing and jumping (while sitting, kneeling, or standing)
  - Linear swinging (using a platform and swing, glider, hammock, and barrel; swinging in the kneeling, standing, sitting, creeping, prone, and supine positions)
  - Other linear activities (jumping or falling onto pillows or mattress in the sitting, prone, and supine positions)

The center of gravity is changed to create disorganization for a short time, and thus phasic head movements appear, which help develop *equilibrium reactions* by increasing semicircular canal responses. The recommended activities are the following:

- Moving the support surface, so that the center of gravity is changed from active to passive.
- Pushing-pulling activities, so that displacement of the center of gravity is created. These are activities that enable active equilibrium on steep surfaces such as stairs, ramps, and other surfaces by using equipment such as balance boards, therapy balls, and a barrel.

- Linear vestibular stimulation is applied at tolerable speeds and durations and in unthreatening positions to *lessen the fear of movement or positional change* by increasing the weak passage of otolith input (Fisher and Bundy, 1989).

Vestibular stimulation should be carefully used and the child should be assessed before, during, and after the intervention session to avoid overstimulation, which in the most serious cases causes dysfunction of vital organs, seizures, and or cyanosis (Fisher and Bundy, 1989).

Neurodevelopmental Treatment Approach

The neurodevelopmental treatment (NDT) is aimed at facilitating and normalizing (1) the hyper- or hypotonic muscle reflexes (postural tonus), with focus on a complex facilitation-inhibition process; (2) reaction and movement patterns; and (3) managing the specific reactions to the treatment equilibrium. NDT uses inhibition as a major factor for the control of movement and posture (Bobath and Bobath, 1967).

The child's functional skills are observed and analyzed, and the intervention is customized with functional activity education. Automatic and voluntary activities, normal postural tonus, normal reciprocal interaction of the muscles, and automatic movement patterns are intervention priorities because all upper motor neuron lesions are disturbances to this mechanism (Mayston 1992).

Combined Intervention Approaches

In children with mental retardation and with attention and emotional problems, cognitive and perceptive skills and motor development are stimulated by a combination of sensory stimulation interventions, such as sensory integration, perceptual-motor activities, neurodevelopmental activities, vestibular stimulation, and play therapy (Ayres, 1972, 1979; Bobath and Bobath, 1967; Bumin and Kayihan, 2001; Uyanik et al., 2003).

The purpose of this intervention is to develop children's appropriate activity experiences that provide stimulus to normal movement patterns and motivate children to participate in the intervention program. The children's interactive participation in the environment is important for the acquisition of skills.

The child actively participates in the intervention process. The skills and roles are practiced, and the child becomes able to discover and integrate sensory information received from the environment by forming meaningful relations with people and objects (Lindquist et al., 1982). This child-centered intervention starts with the observation and facilitation of the child's play in the snoezelen therapeutic rooms or other multimodal sensory rooms. A safe environment is arranged using toys and materials (Bumin and Kayihan, 2001; DeGangi et al., 1993; Uyanik et al., 2003).

The general principles of combined intervention programs are as follows:

- A child's mental development level is considered. Activities that are easy to learn and the comprise the easiest possible movement components are chosen.
- A child's normal reflex motor development is followed for planning the intervention and choosing the appropriate activities. The activities are adapted to the supine-prone, quadruped, sitting, and standing positions.
- The intervention should be performed with the child working alone to avoid confusing effects that may be caused by other people or the room arrangement.
- Equipment is used gradually so that the amount of stimulation is adjusted to the tolerance level of the child.
- In the improvement of sensory-perception-motor responses, the development of proprioceptive feedback is beneficial. Motor responses of the child are increased by using methods such as positioning and movement activities, applying resistance, and by utilizing touch and equilibrium stimuli.
- The program is carried out step by step, from easy to difficult, and should only be changed when the child's skill in the previous step has been accomplished (Bumin and Kayihan, 2001; Uyanik et al., 2003).

Evidence-Based Practice

The sensory integration approach is effective in reducing self-stimulating behaviors, which interfere with the ability to participate in more functional activities (Smith et al., 2005). A meta-analysis of the NDT showed improvement in 62.2% of the disabled children compared with the children who do received the intervention (Ottenbacher et al., 1986). However, evaluation of the sensory integration approach aimed with children who have sensory processing disorders is still an ongoing process whereas its effectiveness needs further investigations (Miller, et al., 2007; Patel, 2005).

Discussion

Mentally retarded children present complex problems including sensory, perceptual, motor, and vestibular dysfunctions. Therefore, the use of sensory integration, vestibular stimulation, and NDT interventions in sequential, parallel, or combined programs conducted by an experienced OT is proved to be effective for improvements that correspond to children's needs for occupational performances.

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