EDUC –S.M.A.R.T. Training

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SEMESTER CREDITS: 1 graduate credit

COURSE DATES: June 28th, June 29th, and June 30th

LOCATION: CESA 5 626 E. Slifer St Portage, WI 53901

DESCRIPTION:

S.M.A.R.T. (Stimulating Maturity through Accelerated Readiness Training) is a multi-sensory approach to teaching and learning that is designed to develop and enhance the critical readiness skills students need to succeed in school. The S.M.A.R.T. Pre-K training helps participants understand how to look at children developmentally and apply activities for developing and /or enhancing students' large and fine motor skills, visual perception and eye-hand coordination, auditory skills, and all necessary tools for learning to read and achieving academic success. Training provided by A Chance To Grow.

Featured Presenter:

Jessica McFarland. Jessica is one of the many trainers that A Chance to Grow sends out to districts to train staff in the SMART training.

Students will attend a three-day conference where they will participate in a hands on training utilizing readiness skills to assist children in a successful school experience.

COURSE ASSIGNMENTS AND REQUIREMENTS:

1. Attend all three training days.
2. Write an application summary paragraph for the THREE (3) days of training.
3. Read **FOUR (4)** articles and summarize how the information applies to daily work assignments.

   (Articles are provided to participants on the conference webpage).
4. **Items # 2 and #3 must be received by Mary O'Brien no later than 4:00 PM on Monday July 25, 2016 in order for the student to receive credit. Please send summaries to my email address,** obrienm@cesa5.org **No handwritten papers will be accepted.**

METHODOLOGY:

Lecture, small group discussion, large group discussion, question and answer sessions, webinars, videos, LCE presentations, overheads, sharing sessions, and other related teaching and presentation aids will all be used during the conference sessions.

WISCONSIN TEACHER STANDARDS ADDRESSED:

PI-34.02 Teacher Standards:

2. The teacher understands how children with broad ranges of ability learn and provides instruction that supports their intellectual, social, and personal development.
3. The teacher understands how pupils differ in their approaches to learning and the barriers that impede learning and can adapt instruction to meet the diverse needs of pupils, including those with disabilities and exceptionalities.
4. The teacher understands and uses a variety of instructional strategies, including the use of technology, to encourage children's development of critical thinking, problem solving, and performance skills.
6. The teacher uses effective verbal and nonverbal communication techniques as well as instructional media and technology to foster active inquiry, collaboration, and supportive interaction in the classroom.
8. The teacher understands and uses formal and informal assessment strategies to evaluate and ensure the continuous intellectual, social, and physical development of the pupil.

PI-34.03 Administrator Standards:

3. The administrator manages by advocating, nurturing and sustaining a school culture and instructional program conducive to pupil learning and staff professional growth.
5. The administrator models collaboration with families and community members, responding to diverse community interests and needs, and mobilizing community resources.
7. The administrator understands, responds to, and interacts with the larger political, social economic, legal, and cultural context that affects schooling.

PI-34.04 Pupil Services Standards:

2. The pupil services professional understands the complexities of learning and knowledge of comprehensive, coordinated practice strategies that support pupil learning, health, safety, and development.

3. The pupil services professional has the ability to use research, research methods, and knowledge about issues and trends to improve practice in schools and classrooms.
5. The pupil services professional understands the organization, development, management and content of collaborative and mutually supportive pupil services programs within educational settings.
6. The pupil services professional is able to address comprehensively the wide range of social, emotional, behavioral, and physical issues and circumstances which may limit pupils' ability to achieve positive learning outcomes through development, implementation, and evaluation of system-wide interventions and strategies.

Viterbo Mission Statement

The mission of Adult Learning at Viterbo University is to be the regional choice for non-traditional students, preparing them to grow as confident professionals in their careers and communities.

GPAE Goals

- To foster an appreciation of the lifelong learning in program participants.
- To teach using active methods of learning through discussion, student involvement, and relevance to the learners' lives.
- To prepare learners for careers or for occupational advancement or change through acquisition of current knowledge and skills.
- To offer courses at times, locations, and in formats convenient to working adults' schedules.
- To provide learning opportunities for adults across Wisconsin and beyond through the use of technology.

Accreditation

Viterbo University is committed to meeting the highest academic standards measured by the North Central Association of Colleges and Schools Commission on Institutes of Higher Education (HLC). The university offers excellent opportunities for students transferring from similar colleges and universities which have net the stringent guidelines of their regional accrediting commissions. We have a liberal transfer policy for students transferring from any of the six accredited institutions. Most often, these are nationally accredited, proprietary/for profit institutions. We urge all students to verify that the institution where they take courses is regionally accredited to ensure that their coursework can be considered for transfer to any regionally accredited university or college at the graduate or undergraduate level.

Viterbo University is accredited/approved by:

- National Council for Accreditation of Teacher Education
- Wisconsin Department of Instruction
- Higher Learning Commission of the North Central Association

OUTLINE OF CONTENT:

1. Course description and outlined expectations (see conference brochure)
2. Current professional journal articles, Wisconsin State – wide Project materials, and on-line resources.
3. Written project describing the application of knowledge and skills acquired through the conference to address an identified professional learning and/or district need.

COURSE OUTCOMES:

1. Participants will learn how to implement brain-stimulating strategies into their school day.
2. Participants will learn the importance of collaborative teaming to support successful classroom readiness.
3. Participants will learn and understand the power of the mind and body, as well as how to use them as motivating factors in both personal and professional circumstances.
4. Participants will learn and understand the methodology of intervention techniques and how to incorporate them into daily lessons to assist in the educational growth of their students.

GRADING/METHODS OF EVALUATION:

Grading Rationale

* Participants in this course are expected to attend the full day institute and complete all (4) four webinars. (NOTE: No papers will be accepted at the conference).

* After careful reading and reflection of the articles and completion of the written assignment, papers may be sent via email, google doc, US Postal Service, faxed to CESA 5. **(But must not be hand written)**

* All activities are to be completed to the satisfaction of the instructor.

* All project expectations and evaluation criteria, including the due date, will be discussed at the institute.

Grading Scale

A	40-45 point
B	35-39 points
C	25-34 points
D	15-24 points
F	0-14 points

OR failure to turn paper in by due date: **July 25, 2016**

Grading Rubric

Written summary paragraph for each session and summaries from four (4) articles.

Three day training summary = Total 20 pts.

Reading summary paper 5 points each = Total 20 pts.

45 Total points

Grading Criteria Total of All Available points 40	Poor 1	Below Average 2	Average 3	Good 4	Excellent 5
Three day training summary 20 points _______points	Paragraph unorganized, no complete sentences, OR no mention of professional connection not made.	Several of the points of the paragraphs are ambiguous OR professional practice connection not made.	Paragraphs have little organization; and a poor connection to professional practice statement.	Paragraphs follow a logical organization but may drift from the session's topic and/or benefit connection to practice statement is acceptable, but could be stronger.	Paragraphs are clear, logical, organized around a developed session's topic. Includes strong benefit to practice statement.
Summary of Reading #1_____ Reading #2_____ Reading #3_____ Reading #4_____ 5 pts/each Total 20 points ______points	The summary does not explain how the article content relates to the application in school or daily work. No paper submitted or submitted late.	The evidence provided does not support the topic of the article; little relation to the school setting, no connection to daily work or examples.	The application and summary attempts to support the topic of the article and its relevance to the school setting only one example given.	The summary explains how the article topic supports the applications to the school setting with at least two examples.	The summary demonstrates a strong relationship between the article topic and application of the topic to the school setting; several strong examples are included.
Total points/ GRADE					

BIBLIOGRAPHY and SUGGESTED READINGS:

Alireza, Shamsoddini, Msc "Comparison Between the Effect of Neurodevelopmental Treatment and Sensory Integration Therapy on Gross Motor Function in Children with Cerebral Palsy", Iran J Child Neurology, Vol4, No 1, June 2010

Arndt, Sherry W. PT, DSc, PCS; Lynette Chandler, PhD; Jane K Sweeny, RT, PhD, PCS; Mary Ann Sharkey PT, PhD; Jan Johnson McElroy, PT, MS " Effects of Neurodevelopmental Treatment-Based Trunk Protocol for Infants with Posture and Movement Disfunction" http://journals.lww.com/pedt/Fulltext/2008/01910/Effects_of_a_Neurodevelopmental_Treatment_Based.3.aspx

Beard Johnson, Emily "How Does Neurological Reorganization Address Attachment Spectrum Disorders?" http://a4everfamily.org/index2.php?option=com_view&id=183&itemid=69&pop-1&page=0

Kayihan, Hulya and Mine Uyanik, Ph.D. "Down Syndrome: Sensory Integration, Vestibular Stimulation and Neurodevelopmental Therapy Approaches for Children" http://cirrie.buffalo.edu/encyclopedia/en/article/48/

Wuang, Yee-Pay, Chih-Chung Wang, Mao-Hsiung Huang, Chwen-Yng Su " Prospective Study of the Effect of Sensory Integration, Neurodevelopmental Treatment and Perceptual- Motor Therapy on the Sensorimotor Performance in Children with Mild Mental Retardation" http://ajot.aota.org/

Prospective Study of the Effect of Sensory Integration, Neurodevelopmental Treatment, and Perceptual–Motor Therapy on the Sensorimotor Performance in Children With Mild Mental Retardation

Yee-Pay Wuang, Chih-Chung Wang, Mao-Hsiung Huang, Chwen-Yng Su

KEY WORDS

- mental retardation
- occupational therapy
- psychomotor disorders
- psychomotor performance
- sensation

OBJECTIVE. This quasi-experimental study compared the effect of sensory integrative (SI) therapy, neurodevelopmental treatment (NDT), and perceptual–motor (PM) approach on children with mild mental retardation.

METHOD. Children ($N = 120$) were randomly assigned to intervention with SI, NDT, or PM; another 40 children served as control participants. All children were assessed with measures of sensorimotor function.

RESULTS. After intervention, the treatment groups significantly outperformed the control group on almost all measures. The SI group demonstrated a greater pretest–posttest change on fine motor, upper-limb coordination, and SI functioning. The PM group showed significant gains in gross motor skills, whereas the NDT group had the smallest change in most measures.

CONCLUSION. SI, NDT, and PM improved sensorimotor function among children with mild mental retardation. The choice of sensorimotor approaches should be determined on the basis of the child's particular needs because each approach may have an advantage in certain aspects of sensorimotor function.

Wuang, Y.-P., Wang, C.-C., Huang, M.-H., & Su, C.-Y. (2009). Prospective study of the effect of sensory integration, neurodevelopmental treatment, and perceptual–motor therapy on the sensorimotor performance in children with mild mental retardation. *American Journal of Occupational Therapy, 63,* 441–452.

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Children with mental retardation are characterized by delays in motor milestone attainment, sensorimotor performance deficit, and perceptual dysfunctions, in addition to significant limitations in both intellectual functioning and adaptive behavior (Batshaw & Shapiro, 2002; Burack, Hodapp, & Zigler, 1998; Hogan, Rogers, & Msall, 2000). Relative to those with moderate or severe mental retardation, children with mild mental retardation are infrequently recognized before school age and may begin to demonstrate the need for rehabilitation and special education services during early school years because of minor difficulties with gross and fine motor tasks that hinder participation in school activities, academic performance, independence in daily living, and social acceptance by peers (Hamilton, 2002; Pivik, McComas, & Laflamme, 2002). These unsuccessful school experiences may further retard social and emotional development in children with mild mental retardation (Sherrill, 1998). Effective therapy to enhance sensorimotor function is thus of paramount importance in facilitating integration into school life and reducing the immediate burden and future expense on the society (Wuang & Niew, 2005).

The most common approaches for treating sensorimotor problems in children with disabilities include *sensory integrative* (SI) therapy, *neurodevelopmental treatment* (NDT), and *perceptual–motor* (PM) approach. SI intervention is based on the premises that sensory input is necessary for optimal function of the child's brain and that early intervention will promote underlying capabilities and minimize abnormal function as a result of plasticity in the central nervous system that is greatest during early childhood (Ayres, 1989). SI therapy is justified in the treatment of children with mental retardation because a common feature in this group of children is a failure to integrate sensory information into adaptive responses that include making judgments about the environment, responding to the environmental challenges with success, and accomplishing the required role imposed by the occupation (Ayres, 2004). The effectiveness of SI therapy on children with disabilities is equivocal. Some studies reported favorable results in terms of the use of SI therapy for the remediation of sensorimotor dysfunctions (Linderman & Stewart, 1999; Stonefelt & Stein, 1998; Uyanik, Bumin, & Kayihan, 2003), whereas other studies concluded that there is insufficient evidence to support the effectiveness of SI therapy in this population of children (Arendt, MacLean, & Baumeister, 1988; Dawson & Watling, 2000). Discrepancies in the outcome of SI therapy may be attributed to the differences in sample characteristics, intensity and duration of intervention, and outcomes measured (Schaaf & Miller, 2005).

The NDT frame of reference focuses on understanding children's difficulties related to muscle tone, stability, and mobility and implements targeted interventions to address these areas of difficulty (Schoen & Anderson, 1999). NDT is appropriate for use in children with mild mental retardation because these children often present with accompanying neuromuscular dysfunction (i.e., unusual posture, hypotonia, poor limb control, atypical muscle activation; Hogan et al., 2000; Hoover & Wade, 1985; Latash, 1992), motor delay (Batshaw & Shapiro, 2002), and poor motor control (Elliot & Bunn, 2004). Similar to the results of the SI approach, the literature is also inconclusive on the effect of the NDT approach in children with disabilities (Adams, Chandler, & Schulmann, 2000; Bar-Haim et al., 2006; Butler & Darrah, 2001). Likewise, interpretation of these findings is confounded by heterogeneous samples, inadequate sample sizes, lack of control group, poorly defined treatment techniques, and inappropriate outcome measures (Butler & Darrah, 2001).

The PM approach assumes a causal relationship between motor behavior and underlying perceptual processes. PM training provides the child with a broad range of experiences with sensory and motor tasks by means of therapist-directed structured activities. General improvement in perceptual and academic abilities is anticipated as a consequence of enhanced sensory and motor experiences (Cratty, 1981). The PM approach to treatment of children with mild mental retardation has a long history reflecting the incidence of perceptual–motor deficits (e.g., specific visual–perceptual disturbances and learning difficulties; Batshaw & Shapiro, 2002; Hoover & Wade, 1985) and continues to be the treatment of choice for many clinicians (Wallen & Walker, 1995). However, in spite of its popularity, a meta-analysis of 180 published studies found only modest treatment effects associated with measures assessing perceptual and sensorimotor functioning for children with disabilities (Kavale & Mattson, 1983). Specifically, the largest effect sizes were seen in children with mental retardation, followed by children with motor disabilities. In light of the fact that PM training literature is constrained by studies with design, measurement, and analysis flaws, these authors suggested that future research should take into account these methodological shortcomings to provide more precise estimates of the effectiveness of PM training.

On the whole, there is no clear consensus regarding the most effective intervention strategies for management of sensorimotor deficits in school-age children with mild mental retardation. Given that motor deficits pervade every aspect of a child's life—from school adjustment to emotional well-being (Hamilton, 2002; Pivik et al., 2002)—there is a legitimate need to evaluate the differential effect of SI, NDT, and PM approaches in this population. The results of this comparison will allow therapists to make a rational decision in the choice of treatment regimens and promote an evidence-based clinical practice. The tests used to measure treatment effects in the current study contained the Bruininks–Oseretsky Test of Motor Proficiency (BOTMP; Bruininks, 1978), the Developmental Test of Visual Motor Integration (VMI; Beery, 1997), and the Test of Sensory Integration Function (TSIF; Lin, 2004). These tests were chosen on the grounds that skills measured in the tests (such as adaptive function and school-related functions) are necessary for children to engage in age-appropriate occupational roles. The BOTMP assesses qualitative aspects of motor behavior in relation to fluency and flexibility of movement (Slaats-Willemse, de Sonneville, Swaab-Barneveld, & Buitelaar, 2005). The VMI was used to tap graphomotor function that involves the use of fingers and hands to create written output (Levine, 2008). The TSIF (Lin, 2004) was used to assess difficulties in the SI process.

Research Hypotheses

We tested the following hypotheses derived from clinical experiences with these treatment techniques in children with mild mental retardation ages 7 to 8:

1. The largest treatment effect with SI therapy will be seen in tasks that require complex sensorimotor processing such as perceptual analysis, motor planning, and sensitivity to feedback.

2. The largest treatment effect with PM therapy will be seen in tasks that require refined perceptual and sensorimotor skills.
3. The largest treatment effect with NDT will be seen in tasks that require functional movement patterns.

Method

Participants

The study was conducted during 2004–2005 in the pediatric occupational therapy unit, Department of Rehabilitation Medicine, of the university-affiliated medical center, after approval by its ethics committee. Inclusion criteria included

- Ages between 7 and 8 years;
- A diagnosis of mild mental retardation determined by the board-certified physicians at local designated hospitals according to the standards put forth by the Department of Health in Taiwan (i.e., IQ 50–55 to 70 on the basis of the Wechsler Intelligence Scale for Children [Wechsler, 1991], existing concurrently with related limitations in two or more of the following applicable adaptive skill areas: communication, self-care, home living, social skills, community use, self-direction, health and safety, functional academics, leisure, and work);
- Absence of serious emotional or behavioral disturbances;
- No participation in physical or occupational therapy programs at the time of research; and
- Ability to follow test instructions.

Children who had coexisting autism, cerebral palsy, blindness, and deafness were excluded in an attempt to minimize confounding of data. Also, children with a previous history of neurological disorders, such as traumatic brain injury, muscular dystrophies, and epilepsy, were excluded.

Children with mild mental retardation were identified from relevant educational and clinical sources. Seventeen elementary schools located in a metropolitan city participated as educational sources in the current study. We contacted the first- or second-grade teachers at each participating school, explained the goals and procedures of the study, and asked them to nominate children eligible for the study. Clinical sources included the health department of a metropolitan city, coupled with its subordinate district health stations, and the Departments of Rehabilitation Medicine and Pediatrics as well as diagnostic and evaluation centers for developmental disabilities at two hospitals in the metropolitan area. Using diagnosis and date of birth, we identified the children by reviewing medical record information contained within the databases compiled by the city's health department and two hospitals, respectively.

One hundred seventy-five children meeting the study criteria were selected through these sources. An attempt was made to contact their parents or primary caregivers to explain the project and request consent. Of these, 15 refused and 160 agreed to participate in the study. Forty of 160 children who had initially agreed to participate in the intervention found that they could not attend because of practical reasons (e.g., time of the sessions) before it started and were assigned to the control group. Although not chosen at random, parents of control children had initially wished to join the therapy group, so, presumably, they formed a satisfactory control group.

Measures

The BOTMP (Bruininks, 1978) is an individually administered test that assesses the motor function of children from ages 4.5 to 14.5 years. The complete battery, consisting of 46 items grouped into eight subtests, provides a comprehensive index of motor proficiency along with separate measures of gross and fine motor skills. Gross motor composite score is derived from performance on four subtests covering running speed and agility, balance, bilateral coordination, and strength, whereas fine motor composite score is based on the three subtests involving response speed, visual–motor control, and upper-limb speed and dexterity. A battery composite score can be obtained by summing the scores for the two composites and the upper-limb coordination subtest. The higher the BOTMP scores were, the better the motor outcome was. The average age-adjusted standard scores for subtests and three composites are 15 (standard deviation [*SD*] = 5) and 50 (*SD* = 10), respectively. Internal consistency reliability for the BOTMP subtests ranged from .38 to .92 (Bruininks, 1978). The estimates of interrater reliability ranged between .63 and .97, with a test–retest reliability of .80 to .94 (Bruininks, 1978). The BOTMP showed moderate correlations (Croce, Horvat, & McCarthy, 2001; Ippensen, 2003) with other motor performance tests such as the Movement Assessment Battery for Children (Henderson & Sugden, 1992) and the Test of Infant Motor Performance (Campbell, Osten, Kolobe, & Fisher, 1993). Age demonstrated a statistically significant effect on the scores for 7 of the 14 items and for the total score of the BOTMP short form (Kambas & Aggeloussis, 2006). In particular, healthy children ages 7 and 8 scored significantly higher than those ages 5 to 7. According to this finding, it was not necessary to adjust for age in our study because our sample was restricted to 7- to 8-year-old children.

The VMI (Beery, 1997) and its two supplemental standardized tests, Visual Perception and Motor Coordination, are designed to screen for visual–motor integration deficits that can lead to learning and behavior problems in children ages 3 to 18 years. The VMI contains a developmental sequence of 27 geometric forms to be copied with paper and pencil. The Visual Perception test requires the child to choose a geometric form identical to the stimulus form among others that look nearly but not exactly the same. In the Motor Coordination test, the child has to trace the same 27 geometric forms with a pencil without going outside the double-lined paths. Each design is scored on a pass–fail basis in the VMI and its supplemental tests. Higher scores indicate better performance. A follow-up assessment of visual perception and motor abilities is recommended in the case of poor performance on the VMI. However, for the purpose of the current study, only the Motor Coordination test was administered in the presence of a low VMI score. Published standard scores of the VMI as well as supplemental tests have a mean of 100 and a standard deviation of 15. The VMI and its supplemental Visual Perception and Motor Coordination tests demonstrated overall good reliability (Beery, 1997). In terms of validity, the VMI correlated highly with chronological age (.80–.90), and with other tests that purport to measure visual–motor integration (Demsky, Carone, Burns, & Sellers, 2000; Erford & Snyder, 2004).

The TSIF (Lin, 2004) is designed to identify SI dysfunction in children ages 3 through 12 years. It consists of 98 items divided into six subtests: postural movement, bilateral integration sequencing, sensory discrimination, sensory searching, attention and activity, and emotional–behavioral reactivity. Each of the items is scored on a 5-point Likert scale (1 = *never* to 5 = *always*) on the basis of the frequency of targeted behavior during the entire observation period. Higher scores indicate poorer performance on sensory integration tasks. Subtest standard scores of the TSIF are based on a distribution having a mean of 50 and standard deviation of 10. Internal consistency for the overall test demonstrated a Cronbach's alpha of .89, whereas test–retest reliabilities for the subtest scores ranged from .82 to .94. The TSIF subtest scores significantly varied as a function of age, gender, and residential location (urban vs. rural; Lin, 2004).

Procedure

Treatment fidelity was verified by an audit of 120 videotaped therapy sessions from six therapists who participated in the intervention stage of the study at approximately 1st week and 6 months of intervention, 60 for each time period, 40 for each group. Two pediatric occupational therapists not involved in the current study separately rated the level of therapist's adherence to specific treatment approach in accordance with the recommended activities listed in the training manual, using a 4-point scale: 1 (*non/irregular*, 0%–24%), 2 (*rather irregular*, 25%–49%), 3 (*rather regular*, 50%–74%), and 4 (*regular*, 75%–100%). The median scores for the adherence of SI, NDT, and PM approaches were 4 across raters and time periods.

Using a computer-generated random table, 120 children were randomly assigned to three equal-sized groups. The core elements of sensory integration intervention process (Parham et al., 2007) formed the basis for our SI program. The SI group (24 boys, 16 girls) was engaged in activities such as linear and circular swinging, tactile-perception, bilateral integration and sequencing, and equilibrium reactions for the purpose of presenting the child with opportunities for various sensory experiences. Linear and circular swinging activities were carried out with platform swing, T swing, and tire swing in different positions (supine, prone, sitting, quadruped, kneeling, standing). Tactile-perception activities involved exploring different textures and feeling various shapes. Bilateral integration and sequencing were facilitated through gymnastics and dance activities, whereas equilibrium reactions were elicited by tilting board or therapeutic ball in different positions. The therapist selected and modified activities according to the child's interest in the activity or response to specific sensory challenges so that the child could experience success in doing part or all of the activity. At the same time, the therapist allowed the child to actively exert some control over activity choice by encouraging the child to initiate and develop ideas and plans for activities. Most important, the therapist entered into a relationship with the child that fostered the child's inner drive to actively explore the environment and to master challenges posed by the environment.

NDT treatment was directed to facilitate normal postural control and movement synergies as well as to promote optimal movement patterns to achieve the best energy-efficient performance through the use of positioning, handling, weight-shifting, and weight-bearing techniques (Howle, 2002). The NDT group (24 boys, 16 girls) was involved in activities such as developmental movement patterns, walking, fine motor skills, and strengthening of antigravity muscles. Developmental movement patterns training consisted of obstacle crawl and use of different body positions (kneeling, half kneeling, and standing) to throw the ball. Walking activities included walking forward, backward, and sideways; walking on a line; animal walking (like monkey and crab); stepping; and galloping. Fine motor activities entailed copying designs, cutting with scissors, and participating in chalkboard activities. Strengthening of antigravity muscles was performed with scooter board games, sit-up exercises, and dowel moving in different ways.

The PM group (29 boys, 11 girls) received fine and gross motor training. Examples of fine motor activities were cutting and pasting, mazes, dot-to-dot puzzles, tracing designs, and educational card games, whereas gross motor activities included jumping jacks, skipping, hopping, and tumbling. An equal amount of time was spent with gross motor and fine motor activities, in which gross motor activities always preceded fine motor activities. However, unlike SI and NDT, no effort was made to control the degree or variety of sensory inputs in performing PM training activities. Nor were the inhibitory or facilitatory handling techniques directly incorporated into the PM approach. The control group (30 boys, 10 girls) did not receive any intervention during the study period.

Each intervention group received a 1-hr session 3 days per week for 40 weeks. Treatment was conducted on an individual basis, and each child was randomly assigned to one of the six therapists who administered SI, NDT, or PM techniques according to the child's assigned group. All treating therapists had more than 5 years of clinical experience in pediatric occupational therapy. To ensure consistency in the treatment techniques delivered to the children within each group, the therapists were required to thoroughly review a training manual before the commencement of the intervention, in which a comprehensive listing of activities used for SI, NDT, or PM was described in detail. Home programs were not provided to the parents or caregivers to minimize possible confounding caused by practice effects and variations of treatment techniques between therapists and parents.

Another six pediatric occupational therapists, who were blind to child group status, administered the BOTMP, VMI, and TSIF to the children before therapy and after therapy, according to standardized procedures provided by the appropriate test manuals. The examiners undertook an intensive 1-day training session led by Yee-Pay Wuang. During training, particular attention was drawn to the tests' explicit nature, administration, and scoring. To meet the competency requirement in test administration, each examiner completed a case under Wuang's supervision to ensure correctness and appropriateness in administering and scoring before formal testing. After training, a video recording of the assessment of one child was made. Each of the six therapists viewed the recording and scored it individually. High interrater reliability with the three instruments was reached, with .94, .97, and .98 for the BOTMP, VMI, and TSIF, respectively. To decrease possible experimenter bias, the examiner did not reacquaint herself with the child's scores from the first assessment when conducting the retest. Children in the intervention groups were tested at the occupational therapy unit, whereas children in the no-treatment control group were tested in a quiet classroom at children's respective schools. The testing was conducted on an individual basis in one session lasting approximately 1 to 1.5 hr, with a suitable number of breaks to minimize the effects of fatigue.

Data Analysis

SPSS 12.0 (SPSS Inc., Chicago) was used to analyze the data. To facilitate analyses, raw scores were first converted to standard scores using the publisher-provided norms. Next, to determine preintervention differences in test performance across four groups, multivariate analysis of variance (MANOVA) was applied with preintervention test scores as dependent measures and group as a between-participants factor. A second MANOVA was conducted to investigate postintervention differences in test performance among groups. If the multivariate test indicated a significant group effect, follow-up univariate *F* tests were performed with Scheffé post hoc comparisons (Portney & Watkins, 2009). To quantify the magnitude of the postintervention difference between intervention and control groups, effect sizes (ES) were calculated as d = [treatment mean – control mean]/*SD*. *SD* was calculated as the square root of the pooled estimate of population variance $[SD^2 = (N_1 \times SD_1^2 + N_2 \times SD_2^2)/(N_1 + N_2 - 2)]$. As a guide to interpreting these values, Cohen (1977) labeled an effect size "small" if $ES \geq .2 < .5$, "moderate" if $ES \geq .5 < .8$, or "large" if $ES \geq .8$. Effect sizes were again computed by dividing the mean change in a test score by the standard deviation of the test score at baseline to quantify the magnitude of change between pre- and postintervention test scores for each group.

Results

Group Comparability

The four groups did not differ significantly in age (F[3, 156] = .41, p = .74) or gender (χ^2[3] = .42, $p > .05$). Before performing the MANOVA, Box's M test (Tabachnick & Fidell, 2006) of equality of covariance matrixes was carried out to test the assumptions of homogeneity of variance. The Box's M test yielded a nonsignificant result (Box's M = 475.95, p = .75); thus, the assumption of homogeneity of variance–covariance matrices was supported. The overall MANOVA for the preintervention test scores was nonsignificant (Wilks' λ = .92, F[48, 420.16] = 0.25, p = 1.00, partial η^2 = .03) and, similarly, none of the univariate between-group comparisons for the BOTMP, VMI, or TSIF were significant (see Table 1). In other words, there was no significant preintervention difference in test scores between the control group and either of the intervention groups.

Postintervention Differences Between Intervention and Control Groups

With regard to the group differences in postintervention test performance, the results of MANOVA revealed a significant overall group effect (Wilks' λ = .00, F[48, 420.16] = 228.84,

Table 1. Summary of the Univariate ANOVAs on the Preintervention Standard Scores for Each Group

Test	Group Mean (SE) Test Scores					
	Control Participants	NDT	PM	SI	F^a	Partial η^2
BOTMP						
Running speed and agility	9.65 (1.12)	9.02 (2.15)	9.23 (1.72)	9.53 (1.11)	1.28	.024
Balance	9.45 (0.99)	9.37 (0.98)	9.50 (1.01)	9.45 (0.99)	0.11	.002
Bilateral coordination	9.65 (1.12)	9.37 (1.13)	9.37 (1.17)	9.50 (1.06)	0.54	.010
Strength	9.45 (0.99)	9.53 (0.99)	9.53 (0.99)	9.53 (0.99)	0.06	.001
Upper-limb coordination	9.95 (0.82)	9.87 (0.79)	9.77 (0.77)	9.92 (0.80)	0.38	.007
Response speed	8.13 (0.79)	8.00 (0.78)	8.08 (0.80)	8.10 (0.78)	0.19	.004
Visual–motor control	7.13 (0.79)	7.10 (0.78)	7.10 (0.84)	7.07 (0.83)	0.03	.000
Upper-limb speed and dexterity	6.88 (0.79)	6.90 (0.78)	6.85 (0.80)	6.88 (0.79)	0.03	.001
VMI	105.23 (11.20)	105.78 (9.01)	106.02 (11.89)	104.80 (9.67)	0.11	.002
Motor coordination	86.08 (5.58)	86.30 (4.60)	85.25 (5.11)	85.50 (5.43)	0.35	.007
TSIF						.005
Postural movement	53.89 (2.77)	53.76 (2.62)	53.50 (2.55)	53.42 (2.43)	0.28	.000
Bilateral integration sequencing	51.93 (1.22)	51.98 (1.23)	51.98 (1.26)	51.95 (1.24)	0.02	.002
Sensory discrimination	65.61 (1.23)	65.74 (1.29)	65.74 (1.29)	65.72 (1.43)	0.08	.001
Sensory searching	63.88 (1.28)	63.74 (1.33)	63.80 (1.28)	63.84 (1.36)	0.07	.001
Attention and activity	58.85 (1.04)	58.78 (1.08)	58.86 (1.02)	58.87 (0.92)	0.07	.002
Emotional–behavioral reactivity	59.75 (1.73)	59.73 (1.70)	59.90 (1.70)	59.81 (1.74)	0.09	.024

Note. ANOVA = analysis of variance; SE = standard error; NDT = neurodevelopmental treatment; PM = perceptual–motor; SI = sensory integrative; BOTMP = Bruininks–Oseretsky Test of Motor Proficiency; VMI = Developmental Test of Visual Motor Integration; TSIF = Test of Sensory Integration Function.
[a]The univariate *F* tests were nonsignificant.

$p < .0001$, partial $\eta^2 = .96$). Figures 1 and 2 illustrate the distribution of means of motor and SI measures for the four groups, respectively. Follow-up univariate F tests were performed accordingly. In light of the number of univariate analyses conducted, the alpha level was set at .003 (.05/16) for all follow-up analyses to maintain a family-wise error rate of less than .05. As shown in Table 2, the four groups performed significantly differently across test measures. The Scheffé multiple comparisons test showed that the SI group significantly outperformed the NDT and PM groups on four BOTMP subtests (upper-limb coordination, response speed, visual–motor control, and upper-limb speed and dexterity) and all of the TSIF subtests, whereas the PM group performed significantly better than the other two groups on the BOTMP running speed and agility, balance, and strength subtests and the motor coordination test (Table 3). On the bilateral coordination subtest of the BOTMP, no significant difference emerged among intervention groups. As for VMI, no significant difference was observed between SI and PM groups in this measure; yet, both groups scored significantly higher than the NDT group. The NDT group performed significantly lower than the SI and PM groups on all measures, with the exception of the motor coordination test. On this measure, the NDT group performed better than the SI group but did not reach a significance level of .003 ($p = .009$).

Inspection of Table 3 also shows statistical significant differences between intervention and no-treatment control groups on all test measures except for the TSIF sensory searching, attention and activity, and emotional–behavioral reactivity subtests and the motor coordination test (see Table 3). On these measures, the NDT group did not significantly differ from the control group. Effect sizes were provided to describe the magnitude of these between-group comparisons (SI vs. control, PM vs. control, NDT vs. control; Table 4). Relative to the control group, moderate to large effect sizes were seen across BOTMP and TSIF measures for the SI group. With regard to children in the PM group, moderate to large effect sizes were achieved for all BOTMP subtests and three TSIF subtests (sensory discrimination, attention and activity, and emotional–behavioral reactivity). Regarding the effectiveness of NDT compared with no treatment, moderate to large effect sizes were obtained on BOTMP gross motor subtests, namely running speed and agility, balance, bilateral coordination, and strength. Taken together, SI and PM groups substantially outperformed the control group on most sensorimotor measures at postintervention, whereas the NDT group showed considerable changes on only several gross motor measures.

Preintervention and Postintervention Differences Within Groups

Estimates of effect size for each group are summarized in Table 5. Cohen's d values for these pre–post comparisons across three intervention groups noticeably exceeded .8,

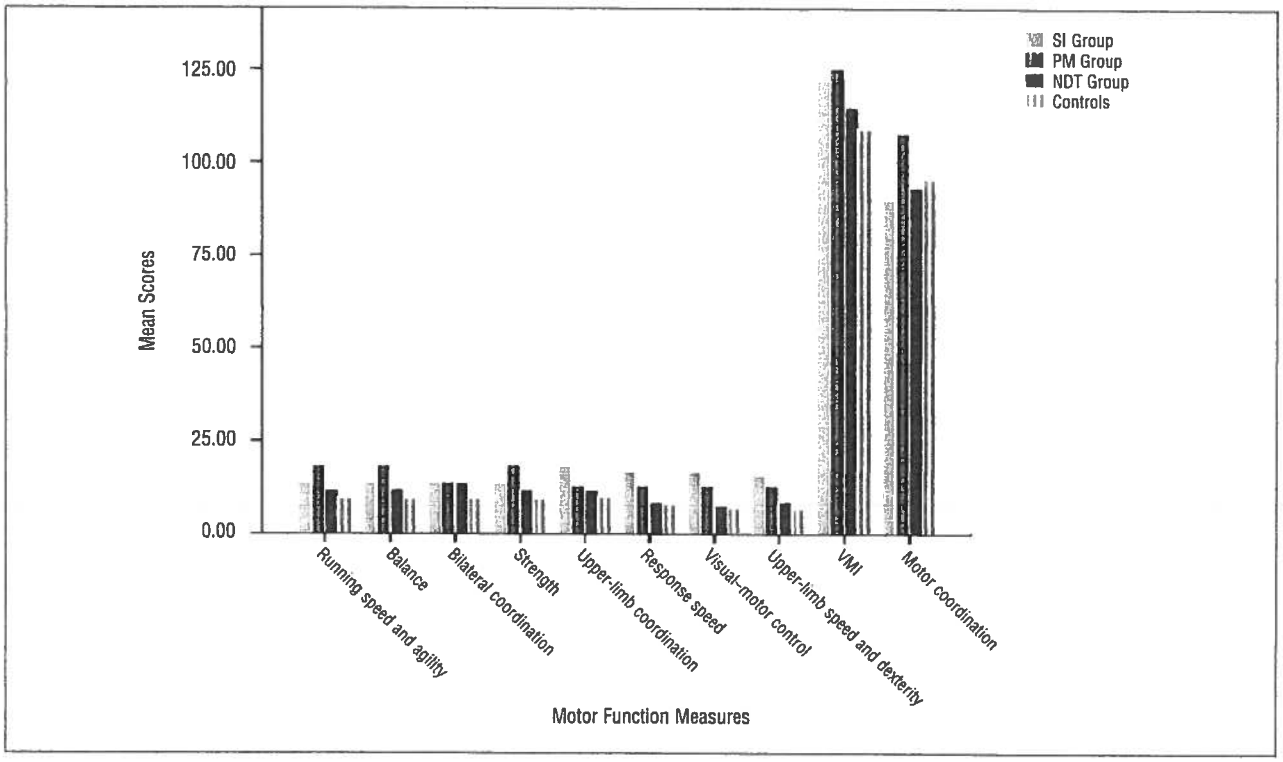

Figure 1. Mean performance of four groups on the Bruininks–Oseretsky Test of Motor Proficiency, VMI, and Motor Coordination test at postintervention.

Note. VMI = Developmental Test of Visual Motor Integration; SI = sensory integrative; PM = perceptual–motor; NDT = neurodevelopmental therapy.

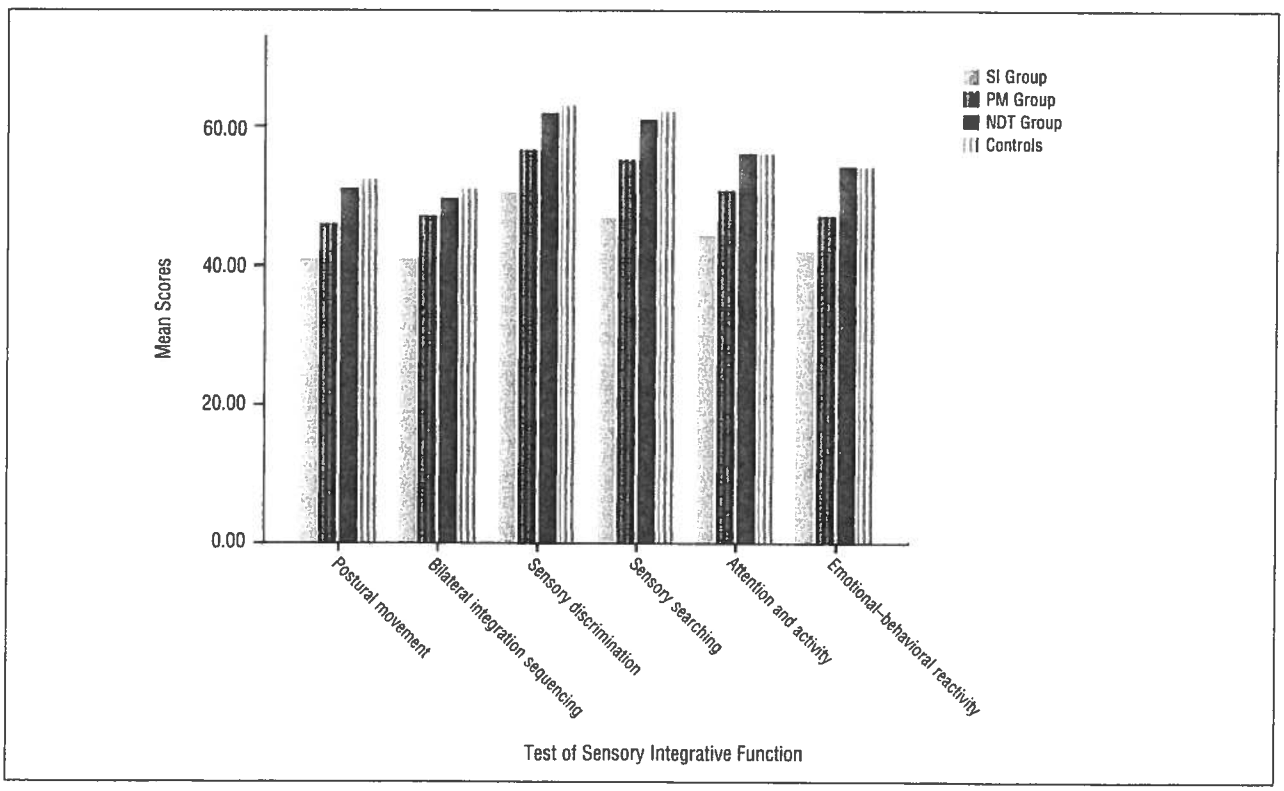

Figure 2. Mean performance of four groups on the Test of Sensory Integrative Function at postintervention.

Note. Lower scores indicated better performance on the TSI. SI = sensory integrative; PM = perceptual–motor; NDT = neurodevelopmental treatment.

Table 2. Summary of the Univariate ANOVA on the Postintervention Standard Scores

Test	Group Mean (SE) Test Scores					
	Control Participants	NDT	PM	SI	F^a	Partial η^2
BOTMP						
Running speed and agility	9.7 (0.1)	12.0 (0.1)	18.5 (0.1)	13.9 (0.1)	780.9	.94
Balance	9.5 (0.1)	12.1 (0.1)	18.5 (0.1)	13.9 (0.1)	708.5	.93
Bilateral coordination	9.6 (0.1)	13.9 (0.1)	13.9 (0.1)	13.9 (0.1)	241.9	.82
Strength	9.6 (0.1)	12.1 (0.1)	18.7 (0.1)	13.9 (0.1)	692.0	.93
Upper-limb coordination	10.0 (0.1)	12.0 (0.1)	13.0 (0.1)	18.5 (0.1)	760.9	.94
Response speed	8.2 (0.1)	8.7 (0.1)	13.0 (0.1)	16.9 (0.1)	1,246.8	.96
Visual–motor control	7.2 (0.1)	7.9 (0.1)	13.1 (0.1)	16.9 (0.1)	1,466.6	.97
Upper-limb speed and dexterity	7.0 (0.1)	8.9 (0.1)	13.1 (0.1)	16.0 (0.1)	1,131.4	.96
VMI	109.2 (1.3)	115.0 (1.3)	125.5 (1.3)	122.0 (1.3)	29.7	.36
Motor coordination	95.7 (0.9)	93.4 (0.9)	107.8 (0.9)	90.1 (0.9)	76.5	.60
TSIF						
Postural movement	52.7 (0.3)	51.4 (0.3)	46.2 (0.3)	41.1 (0.3)	314.6	.86
Bilateral integration sequencing	51.4 (0.2)	49.8 (0.2)	47.3 (0.2)	41.2 (0.2)	358.9	.87
Sensory discrimination	63.4 (0.3)	62.2 (0.3)	56.8 (0.3)	50.9 (0.3)	459.5	.90
Sensory searching	62.5 (0.4)	61.1 (0.4)	55.3 (0.4)	47.1 (0.4)	318.4	.86
Attention and activity	56.3 (0.3)	56.3 (0.3)	51.1 (0.3)	44.6 (0.3)	366.2	.88
Emotional–behavioral reactivity	54.4 (0.4)	54.4 (0.4)	47.3 (0.4)	42.3 (0.4)	236.5	.82

Note. ANOVA = analysis of variance; SE = standard error; NDT = neurodevelopmental therapy; PM = perceptual–motor; SI = sensory integrative; BOTMP = Bruininks–Oseretsky Test of Motor Proficiency; VMI = Developmental Test of Visual Motor Integration; TSIF = Test of Sensory Integration Function.

[a]The univariate *F* tests were significant at the .0001 level.

thereby reflecting robust effect sizes. In particular, SI therapy produced the largest effect sizes in the BOTMP bilateral coordination, upper-limb coordination, and three fine motor subtests and in the VMI as well as TSIF subtests compared with the other two treatment groups. PM training yielded the largest effect sizes in three gross motor subtests of the BOTMP (running speed and agility, balance, and strength) together with the Motor Coordination test. The control group exhibited the smallest magnitude of change across most test measures compared with the intervention groups except for the Motor Coordination test, in which the control group obtained greater gains than the NDT and SI groups.

Table 3. Post Hoc Scheffé Multiple Comparisons at Postintervention

Test	Multiple Comparisons					
	SI–PM	SI–NDT	SI–C	PM–NDT	PM–C	NDT–C
BOTMP						
Running speed and agility	−4.65*	1.85*	4.18*	6.50*	8.83*	2.33*
Balance	−4.63*	1.78*	4.35*	6.40*	8.98*	2.58*
Bilateral coordination	0.00	0.00	4.25*	0.00	4.25*	4.25*
Strength	−4.75*	1.85*	4.30*	6.60*	9.05*	2.45*
Upper-limb coordination	5.50*	6.55*	8.55*	1.05*	3.05*	2.00*
Response speed	3.85*	8.15*	8.70*	4.30*	4.85*	0.55*
Visual–motor control	3.80*	9.05*	9.73*	5.25*	5.93*	0.68*
Upper-limb speed and dexterity	2.83*	7.08*	8.95*	4.25*	6.13*	1.88*
VMI	−3.48	7.03*	12.80*	10.50*	16.28*	5.78*
Motor coordination	−17.73*	−3.33	−5.60*	14.40*	12.13*	−2.28
TSIF						
Postural movement	−5.09*	−10.28*	−11.62*	−5.19*	−6.53*	−1.34*
Bilateral integration sequencing	−6.15*	−8.65*	−10.22*	−2.51*	−4.07*	−1.57*
Sensory discrimination	−5.92*	−11.26*	−12.47*	−5.34*	−6.55*	−1.21*
Sensory searching	−8.20*	−14.00*	−15.38*	−5.80*	−7.19*	−1.39
Attention and activity	−6.46*	−11.70*	−11.70*	−5.24*	−5.24*	0.00
Emotional–behavioral reactivity	−5.00*	−12.10*	−12.10*	−7.10*	−7.10*	0.00

Note. SI = sensory integrative; PM = perceptual–motor; NDT = neurodevelopmental treatment; C = control participants; BOTMP = Bruininks–Oseretsky Test of Motor Proficiency; VMI = Developmental Test of Visual Motor Integration; TSIF = Test of Sensory Integration Function.

*$p < .003$.

Table 4. Summary of Effect Sizes (Cohen's *d*) for Postintervention Differences Between Intervention and Control Groups

Test	SI–Control	PM–Control	NDT–Control
BOTMP			
Running speed and agility	0.81[a]	1.58[a]	0.51[b]
Balance	0.86[a]	1.25[a]	0.57[b]
Bilateral coordination	0.84[a]	0.84[a]	0.88[a]
Strength	0.83[a]	1.18[a]	0.57[b]
Upper-limb coordination	1.19[a]	0.67[b]	0.46[c]
Response speed	1.73[a]	1.04[a]	0.13
Visual–motor control	1.96[a]	1.11[a]	0.16
Upper-limb speed and dexterity	1.88[a]	1.22[a]	0.37[c]
VMI	0.30[c]	0.23[c]	0.12
Motor coordination	–0.18	0.34[c]	–0.05
TSIF			
Postural movement	–0.68[b]	–0.49[c]	–0.25[c]
Bilateral integration sequencing	–0.99[a]	–0.40[c]	–0.15
Sensory discrimination	–0.84[a]	–0.72[b]	–0.12
Sensory searching	–0.63[b]	–0.42[c]	–0.16
Attention and activity	–0.58[b]	–0.71[b]	0.00
Emotional–behavioral reactivity	–0.83[a]	–0.65[b]	0.00

Note. To quantify the magnitude of the difference between intervention and control groups at postintervention, effect sizes were calculated as d = [treatment mean – control mean]/*SD*. *SD* was calculated as the square root of the pooled estimate of population variance [$SD^2 = (N_1 \times SD_1^2 + N_2 \times SD_2^2)/(N_1 + N_2 - 2)$].

[a]A Cohen's $d \geq .8$ indicates a large effect size.

[b]A Cohen's $d \geq .5 < .8$ indicates a medium effect size.

[c]A Cohen's $d \geq .2 < .5$ indicates a small effect size.

Discussion

Of the three intervention groups, children who received PM therapy demonstrated the largest increase in postintervention scores on the BOTMP gross motor subtests and the Motor Coordination test. These improvements may be accounted for by the corresponding training in the subtest content. That is, the skills tapped by the previously mentioned measures, such as running, walking, muscle strength, and tracing geometric figures with a pencil, were more likely to be acquired through repeated practice. Consequently, task-oriented training focusing on activities similar to those measured by the BOTMP gross motor subtests and Motor Coordination test, as is the case of PM approach, may enable children to more readily transfer the training effects on the test tasks. This finding is consistent with those of other studies, indicating that PM-treated children with learning disabilities or developmental delays exhibit significant gains over the SI and no-treatment control groups in gross motor and design-copying performance (Humphries, Wright, Snider, & McDougall, 1992; Wuang & Wang, 2002).

On the contrary, the SI group achieved the greatest progress primarily in the BOTMP fine motor subtests. A probable explanation is that success with skilled fine motor tasks is superimposed on sophisticated motor control and higher-level motor planning. SI therapy promotes an optimal

Table 5. Summary of Intervention Gains and Effect Sizes for Each Group

	SI		NDT		PM		Control	
Test	Change	Cohen's *d*	Change	Cohen's *d*	Change	Cohen's *d*	Change	Cohen's *d*
BOTMP								
Running speed and agility	4.32	3.90[a]	2.98	1.38[a]	9.27	5.40[a]	0.03	0.03
Balance	4.43	4.49[a]	2.73	2.79[a]	9.00	8.88[a]	0.08	0.08
Bilateral coordination	4.38	4.12[a]	4.51	4.01[a]	4.51	3.85[a]	–0.02	–0.02
Strength	4.37	4.43[a]	2.52	2.55[a]	9.12	9.24[a]	0.15	0.15
Upper-limb coordination	8.58	10.77[a]	2.08	2.63[a]	3.23	4.21[a]	0.00	0.00
Response speed	8.78	11.29[a]	0.73	0.93[a]	4.96	6.22[a]	0.05	0.06
Visual–motor control	9.83	11.86[a]	0.75	0.96[a]	6.00	7.13[a]	0.05	0.06
Upper-limb speed and dexterity	9.07	11.47[a]	1.98	2.54[a]	6.28	7.83[a]	0.12	0.15
VMI	17.18	1.78[a]	9.17	1.02[a]	19.43	1.63[a]	3.94	0.35[c]
Motor coordination	4.60	0.85[a]	7.13	1.55[a]	22.57	4.42[a]	9.62	1.73[a]
TSIF								
Postural movement	–12.35	–5.08[a]	–2.41	–0.92[a]	–7.34	–2.88[a]	–1.20	–0.43[c]
Bilateral integration sequencing	–10.76	–8.69[a]	–2.15	–1.74[a]	–4.65	–3.70[a]	–0.53	–0.44[c]
Sensory discrimination	–14.81	–10.35[a]	–3.57	–2.78[a]	–8.91	–6.93[a]	–2.23	–1.82[a]
Sensory searching	–16.70	–12.29[a]	–2.60	–1.95[a]	–8.46	–6.61[a]	–1.36	–1.06[a]
Attention and activity	–14.26	–15.48[a]	–2.47	–2.30[a]	–7.79	–7.64[a]	–2.54	–2.44[a]
Emotional–behavioral reactivity	–17.46	–10.05[a]	–5.29	–3.11[a]	–12.55	–7.40[a]	–5.31	–3.06[a]

Note. SI = sensory integrative; NDT = neurodevelopmental treatment; PM = perceptual–motor; change = mean difference scores (post minus preintervention test standard scores); BOTMP = Bruininks–Oseretsky Test of Motor Proficiency; VMI = Developmental Test of Visual Motor Integration; TSIF = Test of Sensory Integration Function.

[a]A Cohen's $d \geq .8$ indicates a large effect size.

[b]A Cohen's $d \geq .5 < .8$ indicates a medium effect size.

[c]A Cohen's $d \geq .2 < .5$ indicates a small effect size

sensory intake by allowing the child to actively explore and organize diverse sensory inputs. An overall improved organization of sensory input may subsequently enhance motor planning and sequencing ability, thereby leading to the improvement in fine motor skills (Humphries et al., 1992).

Not surprisingly, the SI group demonstrated the largest increase in all TSIF subtest scores after intervention. This result offers direct evidence that children with mild mental retardation are able to benefit from SI therapy to optimize the integrated processing of sensory cues and motor responses. In terms of the effectiveness of NDT, the poorer progress in almost all test measures compared with the SI and PM groups may be ascribed to the fact that children with mild mental retardation seldom present with hard neurological signs that are purported to be responsive to the NDT intervention. Overall, our findings highlighted that the choice of intervention method in the sensorimotor domain should be varied according to each child's particular profile of performance. For example, SI therapy becomes more favorable compared with PM or NDT for the treatment and alleviation of fine motor and SI problems, whereas the PM approach, a form of task-specific training, results in larger gains in targeted gross motor and perceptual–motor skills. SI therapy is also an appropriate treatment for fine motor difficulties seen in children with mild mental retardation or for children without obvious motor deficits who cannot adapt successfully in response to environmental demands.

Unexpectedly, the control group showed a greater gain than the SI and NDT groups in the motor coordination test. This finding may be partly attributable to the disparity in school environment between urban and rural areas. In fact, 75% of control children attended schools in urban metropolitan areas, whereas 87.5% of children in the SI and NDT groups, respectively, were recruited from rural schools. Schools in the metropolitan area were more likely to provide an enriched environment that is filled with a broad array of sensory and motor experiences (especially handwriting and classroom tasks) and materials that allow the children to learn and practice. The statistically significant superiority of the PM approach over the other approaches on motor coordination can be explained by the fact that SI and NDT were not task oriented compared with the PM approach. Moreover, taking into account that 82.5% of children in PM group also came from rural schools, it is reasonable to conclude that PM therapy contributed most to the enhancement of fine motor eye–hand coordination skills.

This study was the first to systematically assess the effects of three therapy approaches on sensorimotor performance in school-age children with mild mental retardation. The differential effects of SI, NDT, and PM on different aspects of sensorimotor function supported all three of our hypotheses. These findings also provided empirical credence to the perceptions of parents, therapists, and teachers that therapeutic intervention using SI, NDT, or PM is effective in improving sensorimotor function to varying degrees in children with disabilities compared with no treatment (Cohn, 2001; Wuang & Niew, 2005).

The strengths of this study include the provision of a clear operational definition for the diagnosis of the study sample, well-defined interventions, inclusion of a no-treatment control group for a valid interpretation of treatment effects, an equal number of children within each group with an equal gender distribution, and use of psychometrically sound test instruments. There were some limitations with respect to the nonequivalent control group, restricted age range of the study sample, differences in the intensity and frequency of home practice with techniques taught in the therapy sessions, and lack of long-term follow-up to discern long-term impact of the interventions on the children's motor development. First, the possibility that those who moved to the control group were different in several respects cannot be ruled out. For instance, parents of control children might have been less motivated to bring their children for any type of therapy. In addition, as opposed to children in the intervention groups, a high percentage of control group children were enrolled in urban schools where structured sensorimotor activities are more accessible to them. However, the estimation of intervention effects is less likely to be biased because no differences in age, gender, or preintervention performance were found between the children with and without intervention. Second, because the current study was limited to children in Grades 1 and 2, future research is recommended to study the effect of different intervention approaches on older children in other grade levels to increase the generalizability of results. Third, owing to the large sample size and long treatment duration used in our study, it was difficult to control for the amount of practice time at home. Future studies could consider the covariate of practice effect by having parents record the type and frequency of physical activities carried out at home in a log on a daily basis. Finally, the results of the current study reflect the training effects during a 40-week training intervention. Continued improvement or maintenance of sensorimotor abilities would strengthen support for either type of intervention. Therefore, replication of this study with a long-term follow-up (e.g., 1 or 2 years after intervention) is warranted.

In conclusion, therapeutic intervention (i.e., SI, PM, NDT) conducted on a regular basis was beneficial in improving sensorimotor functions in school-age children with mild mental retardation. More effort should be made to help these children generalize the training effects to the functional tasks that demand similar motor skills. ▲

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Research Report

Effects of a Neurodevelopmental Treatment-Based Trunk Protocol for Infants with Posture and Movement Dysfunction

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Abstract

Purpose: This study was used to evaluate the efficacy of a neurodevelopmental treatment (NDT)-based sequenced trunk activation protocol for change in gross motor function of infants aged 4 to 12 months with posture and movement dysfunction. Infants who received a dynamic co-activation trunk protocol were compared with a control group who received a parent-infant interaction and play protocol.

Method: A repeated measures randomized block design was used. A masked reliable examiner assessed infants before, immediately after, and 3 weeks after intervention using the Gross Motor Function Measure (GMFM).

Results: The NDT-based protocol group made significantly ($P = 0.048$) more progress than the control group from pretest to posttest.

Conclusions: Cautious support was found for (1) sequenced, dynamic trunk co-activation intervention compared to generalized infant play; (2) high-frequency, short-term, task-specific intervention; and (3) direct service by NDT-trained pediatric therapists specializing in infant intervention.

INTRODUCTION

Federal legislation in the United States protecting the rights of all children and youth to an appropriate education, including access to pediatric therapy, is extended to infants and toddlers. Although state, federal, insurance, and private monies are expended for infants and children with developmental delays, research evidence remains inconclusive on the best treatment for infants with gross motor delays.

Neurodevelopmental treatment (NDT) for infants is an approach commonly used by pediatric therapists for infants with posture and movement dysfunction. Despite the widespread use of NDT in pediatric therapy, few well-designed studies exist that systematically investigate the short- or long-term benefits of the NDT approach for infants. Authors of meta-analytic reviews[1–5] report positive trends, but inconclusive evidence, on the efficacy of NDT in improving independent functional movement and postural control for infants and children with cerebral palsy (CP) or with high risk factors predisposing them to CP. As a commonly used approach in pediatric therapy, it is important that we have more definitive research on the efficacy of the NDT treatment approach for infants.

Eight randomized controlled trial (RCT) studies[6–13] on the efficacy of early therapy for infants were identified in the literature in the last 20 years. Five of the RCT studies[6,7,10–12] were conducted with infants younger than 1 year as subjects. The participants in these five studies were infants born prematurely and identified by high risk factors predisposing them to the development of CP. Researchers in three of the RCT studies[6,7,12] reported in subsequent articles[8,9,13] results of extended follow-up (FU) for the same infant populations. With the exception of one study[12] that used a combination of NDT and sensory integration (SI), no treatment was investigated in these studies other than the NDT approach. Except for the Girolami and Campbell study,[10] the NDT therapy was vaguely defined with no identified protocol and therapy providers were not cited as having received specific NDT infant

Researchers in four of the five studies[6–9,11–13] reported nonsignificant results on the efficacy of pediatric therapy to improve outcomes for infants with high neuromotor risk on any of the postintervention outcome measures at 1 year of age,[6,7,11,12] and on extended FU assessments at 18 months,[12] 24 months,[8,12] 30 months,[11] 4 years,[13] or 6 years of age.[9] In all studies, methodological problems were identified: (1) absence of identified functional delay in study participants[6–9,11–13]; (2) infrequency of intervention[6–9,11–13]; (3) lack of rater reliability and validity in outcome measures[6–9,11–13]; and (4) absence of operationally defined NDT intervention protocols.[6–9,11–13]

Girolami and Campbell[10] conducted the single study that included an operationally defined NDT-protocol intervention. The NDT-protocol training. All investigators in the eight RCTs[6–13] examined the following question: Does early pediatric therapy intervention improve outcomes for infants with high risk for CP?

was delivered 12 to 15 minutes twice daily for 7 to 17 days by a Neurodevelopmental Treatment Association (NDTA) instructor with expertise in infant treatment. The researchers studied 19 infants at postconceptual ages of 34 to 35 weeks in a special care nursery. To assess postural control, they used the Supplemental Motor Test, a precursor of the Test of Infant Motor Performance (TIMP).[14,15] Even with a small sample size and short intervention duration, statistical significance ($P = 0.002$) for improved postural control in prematurely born infants was reached in the NDT-protocol intervention for infants with high neuromotor risk compared with a matched control group who received identical amounts of attention and positioning. When the eight RCTs were compared, Girolami and Campbell's[10] was the only investigation in which a significant change was reported.

To avoid the methodological problems identified in the RCT studies[6-9,11-13] discussed above, the study presented here used an operationally defined protocol, therapy providers with specialized infant training, high frequency of intervention, and a valid outcome measure for infants with posture and movement dysfunction. This study took place within the context of a 3-week NDTA Advanced Baby Course. The course was based on the NDT problem-solving process for managing sensory-motor impairments in infants aged 4 to 12 months. The general theoretical assumptions and application of the NDT approach used in the NDT Advanced Baby Course were described by Howle in 2002.[16] Infants in this study demonstrated gross motor delays with posture and movement dysfunction that were characterized by impairments in orienting responses of the head and trunk.

The capacity of a single study to be used to demonstrate the efficacy of an entire approach is generally considered outside the realm of possibility in today's research environment. An approach, such as NDT, that can be individualized to meet the needs of persons with different diagnoses across the lifespan is inherently too variable to be studied in its entirety. Instead, specific aspects of such an approach can be investigated using well-designed studies with operationally defined protocols and homogeneous participant groups.

An operationally defined protocol was used in this study specifically to address the role of trunk activities in orienting responses as they relate to functional motor skills in infants. By using an operationally defined protocol that was linked to a specific impairment common to a group of infants with posture and movement dysfunction, the authors of this study examined the efficacy of a single aspect of the NDT approach: sequenced dynamic trunk co-activation intervention. Although the trunk activation activities used in this study are not previously published as a protocol in this form, the concepts and facilitations employed in the protocol have been taught in the NDT approach and are not the original work of the authors.

Purpose

This study was designed to evaluate the efficacy of a NDT-based sequenced trunk co-activation protocol for change in gross motor function in infants with posture and movement dysfunction. A group of infants who received a dynamic trunk protocol during functional activities was compared with a group of infants who received a parent-infant interaction and play protocol. The parent-infant group was used to control for attention, maturation, and environment. Both groups received study intervention in addition to their routine ongoing early intervention (EI) services by therapists and teachers.

It was hypothesized that (1) infants with posture and movement dysfunction receiving an infant NDT-based sequenced trunk co-activation (STA) protocol for 10 hours over 15 days would make greater gains in gross motor function compared to infants receiving a parent-infant play (PIP) protocol for 10 hours over 15 days; and that (2) infants with posture and movement dysfunction receiving 10 hours of an infant NDT-based STA protocol would maintain gains in gross motor function at the 3-week FU evaluation session.

METHOD

Study Design

A repeated-measures randomized block design was used for this study. After meeting criteria for the study, infants with posture and movement dysfunction were stratified by severity of disability, ie, mild, moderate, severe impairments. They were then randomly assigned to either a STA treatment or PIP comparison group. Infants in both groups received 10 one-hour intervention sessions over a 15-day period in addition to their routine ongoing EI therapeutic services. The outcome measure was administered before, immediately after, and 3-weeks after intervention. The duration of the study was 8 weeks. The NDT-based STA protocol intervention was employed in the treatment practicum portion of a 3-week NDTA Advanced Baby Course.

Participants

A purposive sample of convenience was used. Of the infants referred by community healthcare agencies in the greater Houston, Texas area, 19 infants between the chronological/adjusted age of 4 to 12 months with gross motor delays, parental consent, and primary care physician prescription met the inclusion criteria for the study. Infants were identified as having posture and movement dysfunction if they scored at or below the 5th percentile rank on the Alberta Infant Motor Scale (AIMS)[17] and met one of the following criteria as defined by the Movement Assessment of Infants (MAI)[18]: (1) delay or asymmetry in lateral or extension head-orienting responses; or (2) delay or asymmetry in trunk-orienting responses. Infants with chromosomal syndromes, severe mental retardation, or congenital anomalies were excluded from the study. Distribution and degree of resistance to passive movement (high, fluctuating, and low) and the AIMS score distinguished the level of motor severity for stratification before randomization into groups.

Instrumentation.

The AIMS[17] and the MAI[18] are discriminative tools employed in this study to identify infants with and without posture and movement

The Gross Motor Function Measure 88 (GMFM) was used to evaluate the effects of the 10 intervention sessions on gross motor skills. The dysfunction who met the inclusion criteria. Both tools have high validity and reliability for discriminating motor behavior.[17,18] The AIMS is a norm-referenced discriminative measure that identifies infants with or without delayed motor abilities.[17] The MAI focuses on components of movement as well as on functional skills and is the only tool found to specifically identify postural components for head- and trunk-orienting.[18]

GMFM is one of the few validated scales available for use as an evaluative tool to measure change in gross motor function over time for infants and children with CP.[19] Russell et al[19] reported intrarater and interrater reliability for repeated administration of the GMFM [intraclass correlation coefficient (ICC) r = 0.96–0.99]. They also reported a relationship between observed clinically important change, using parental and therapist judgment of the magnitude and importance of change in gross motor function, and actual GMFM-determined change. The GMFM was selected as an outcome measure in this study because it reflects both clinically important and quantitative changes.

One month before this study, two trained and experienced GMFM raters established interrater reliability using two sample GMFM videotaped testing sessions. The $ICC_{(3,1)}$ for these sessions was r = 0.92 to 0.97.

Procedures

During the week before intervention, the GMFM was administered to study infants by the reliable rater who was masked to group assignment. Intervention for both groups was 10 one-hour sessions conducted over a 15-day period in adjacent, identical rooms. In addition to the study intervention, participants continued to receive EI therapeutic services as identified on their Individualized Family Service Plan. Parents were responsible for tracking type and frequency of the EI therapeutic services received by their infants during the study duration (Table 1).

Table 1

Intervention

Sequenced Trunk Activation.

Infants in the STA group received intervention delivered by pediatric physical, occupational, or speech therapists previously trained in an 8-week NDTA pediatric course. These therapists had treated infants for at least a year after the 8-week course and were pursuing specialized advanced NDT training for infants. The STA protocol intervention was embedded in the 3-week NDTA Advanced Baby Course curriculum and implemented within the treatment practicum portion of the course. All infants received an examination delivered by the practicum therapist for the purpose of intervention planning. The examination followed published NDT guidelines: (1) history and parental concerns/needs; (2) examination of functional skills in the context of life roles; (3) examination of posture and movement components, eg, alignment, weight shift, base of support, movement strategies, postural control, as they relate to functional activity skills and limitations (Appendix A, Fig. 3, Fig. 4); and (4) systems review to determine the impact of system and subsystems as they relate to functional activities and limitations, eg, respiratory, visual, cardiovascular, neuromuscular, musculoskeletal systems.[16(p.181–253)] Each individualized intervention plan was developed to meet the functional goals collaboratively established by the parents, therapists, and course faculty based on infant and parent needs and concerns. The intervention sessions emphasized transitional activities (eg, rolling, prone to sitting, sitting to quadruped to sitting, quadruped to standing) and followed a fluid sequence of engage, prepare, align, activate repetition, and home repetition. The STA protocol intervention was applied specifically to the "activate" portion of each activity sequence (Appendix A). Execution of the STA protocol involved (1) facilitation of a dynamic co-activation of trunk flexors and extensors in the sagittal plane that is adequate to the demands of a specific functional activity, (2) facilitation of active weight shifting in the frontal plane to produce "elongation on the weight-bearing side," while maintaining the appropriate dynamic co-activation of trunk flexors and extensors,[16] and (3) facilitation of active functional trunk rotation in the transverse plane, while maintaining dynamic co-activation of trunk flexors and extensors and active trunk elongation of the weight-bearing side. Functional trunk rotation is considered to be integral to the development of equilibrium behaviors for variability in motor responses[20] and higher level balance.[16(p.41)] The facilitation of functional trunk rotation within each session is dependent upon the age of the infant and the specific functional skill within the chosen activity.

Fig. 3

Fig. 4

Each step in the STA protocol creates the base needed for the next step in the sequence. Intervention that incorporates the STA protocol produces dynamic trunk co-activation in sequenced trunk movements adequate for the demands of transitional activities. In an infant-led session, the individualized application of the protocol may seem different for each infant and vary within a session depending on the functional activity of interest to the infant.*

Parent-Infant Play Group.

Infants in the PIP group received enriched PIP activities delivered by their parents who were guided by a licensed Child Life Specialist (Appendix B). The primary aim of the PIP was parent-infant interaction and enriched directed play for visual, tactile, auditory, social, cognitive, emotional, and communication developmental skills.[21] Although not individualized or specifically selected for trunk activation, all activities chosen by the Child Life Specialist were appropriate for the age group of infants and inherently encouraged motor skills, eg, head control, weight shifts in prone, reaching, and sitting, for the infant to participate in the interaction and play activities. An aerobics instructor (specialist in postpartum exercises) provided experiential exercise opportunities for parent and infant while doing activities of daily living, eg, pushing a stroller, playing with their infants, picking up and putting down their infants. Led by a psychology graduate student (mother of a child with CP), the parents also had an opportunity for parent-to-parent sharing and problem solving.

Data Analysis.

The data were analyzed using repeated-measures, nonparametric statistics. Nonparametric statistics were used because the sample was small and did not meet the assumptions of normality and homogeneity of variance required for parametric statistics. A one-tailed test of significance was congruent with the alternative hypotheses. The level of significance (alpha) was held at 0.05 to protect against a Type I error. The within-group analyses examined mean GMFM group scores over time, ie, pretest, posttest, 3-week FU, using the Friedman two-way analysis of variance by ranks statistic, $\chi^2\ r$, for each group. When $\chi^2\ r$ was significant, post hoc, pairwise differences were tested with Wilcoxon signed-ranks statistic. The Mann-Whitney *U* test was used to detect between-group differences on the change of mean GMFM group scores, ie, pretest to posttest, posttest to 3-week FU, and pretest to 3-week FU.

RESULTS

Of the 19 infants randomized into two groups, only 10 infants (STA: n = 5, PIP: n = 5) completed at least 80% of the intervention sessions, attended both posttest sessions, and were included in the statistical analysis. Despite participant attrition, there was no significant difference between groups on variables that might have affected their response to intervention (Table 2).

Table 2

The STA within-group mean GMFM scores (Fig. 1) were significantly different over time ($P = 0.01$). Post hoc comparisons for pretest to posttest STA intervention were significant ($P = 0.02$), and pretest to 3-week FU were also significant ($P = 0.02$). Although the PIP group experienced a positive trend in their GMFM scores pretest to postintervention, the within-group difference in the PIP mean GMFM group scores were not significantly different ($P = 0.08$) over time. The between-group difference on the change of mean GMFM group scores was significant ($P = 0.048$) from pretest to posttest in favor of the STA protocol group (Fig. 2). The first hypothesis that infants with posture and movement dysfunction receiving 10 hours of an infant NDT-based STA protocol would make greater gains in gross motor function compared with infants attending 10 hours of a PIP protocol group was supported.

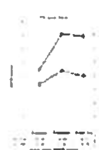

Fig. 1

Fig. 2

For the STA protocol group, there was no significant difference ($P = 0.25$) between posttest and 3-week FU mean GMFM group scores. For the PIP group no significant difference was found between posttest and 3-week FU. The second hypothesis that the NDT-based STA protocol group would maintain motor gains at the 3-week FU session was supported.

The between-group difference of the mean GMFM change group scores, pretest to 3-week FU, was not significant ($P = 0.11$). The GMFM mean group scores in both groups demonstrated high within-group variance during this 3-week postintervention period. This high variance was likely responsible for the nonsignificant differences between groups, pretest to 3-week FU.

Power Analysis.

The study sample size estimate (n = 20 per group) was calculated a priori to provide 80% power at the 0.05 alpha level based on an unpaired two-group comparison of pre-to-postintervention change scores with a one-tailed hypothesis. The power calculations were based on the minimally important effect size index being "large" by Cohen's conventions for unpaired comparisons.[22(Table C.2, p.720)] This means that the study would have had an 80% chance of obtaining $P \leq 0.05$ on the comparison of score changes if the true difference of the mean changes had been 0.8 times as large as the within-group variability of the changes (ie, the pooled within-group standard deviation).

Because of attrition and local policies, the analyzed sample size was 5 per group. Statistical power for this study based on the actual sample sizes of n = 5 per group, and using the a priori estimations (ie, effect size index 0.8, $P < 0.05$, one-tailed hypothesis) would have been approximately 31% if the estimations had been accurate. Although the sample size was smaller than originally planned, it turned out that the observed effect size was considerably larger than the original estimate. The nonparametric Mann-Whitney *U* statistic did reflect a significant group difference, $P = 0.048$, given the observed 8.2 mean group change difference (GMFM points), with an observed effect size index of 1.12. Post hoc power was 49% when computed using the observed values and actual sample sizes in the study groups. We recognize that the small sample size in this study is necessarily linked to imprecision in the point estimate of the treatment effect. Therefore, the results of this study will need replication in a future trial with a larger sample size.

Clinically Important Change.

Infants in the NDT-based STA protocol group made a mean change on the GMFM of 13.3 and the PIP group made a mean change on the

Russell et al[19] calculated the relationship of the actual change in GMFM scores to parental and therapist judgment of the magnitude and

GMFM of 5.1 at the end of intervention. These numerical scores used for the statistical analyses of the study do not describe the clinically important change in function that is often more relevant to parents and therapists.

importance of change in gross motor function. Russell et al[19] determined a "large positive change" in gross motor function as judged by parents and therapists was reflected by an actual GMFM change of 11.4 and 24.6, respectively; a "medium positive change" was reflected by an actual change of 5.2 and 7.0, respectively; and a "small positive change" was reflected by an actual change of 2.7 and 3.8, respectively. For example, the mother of an infant in this study with a 13 GMFM change score reported, "he is able to sit up now longer and not fall over. He has even been able to sit up by himself a few times. He can use his left hand now to pick up toys and it is staying open more of the time. And he is starting to try to stand up in his crib." The mother of an infant with a 7.7 GMFM change score, pretest to posttest, reported, "he can now hold his head up when I hold him and look around. He is now rolling over from his back to stomach and trying to sit up. He is much more alert." An infant whose GMFM change score was 0.72 after the intervention was reported by his mother to "look attentively around and laugh and smile."

According to the findings of Russell et al,[19] the STA group mean change on the GMFM of 13.3 would be described by the parents as a "large positive" change. Therapists would describe the same change as a "medium" to "large" change. The PIP group made a mean change on the GMFM at the end of intervention of 5.1. This score would be described as a "medium positive" change by the parents and a "small" to "medium" positive change by therapists.

DISCUSSION

Improvement in gross motor skills may be achieved with therapeutic intervention of high frequency and short duration for a defined population of infants using an operationally defined intervention protocol and delivered by therapists with advanced, specialized training. The investigators in this study provide evidence for infants with posture and movement dysfunction when interventions are focused on facilitation of dynamic co-activation of trunk flexors and extensors that supports the demands of a specific functional activity. The results have policy implications with regard to (1) generalized play approach delivered by early interventionists or direct intervention from licensed professionals, (2) specific protocols of intervention, and (3) quantity of therapeutic intervention.

Improvement in Motor Function

The NDT approach when applied according the published principles and assessment guidelines with intervention structured according to the sequenced trunk activation protocol seems to produce improved motor performance when provided to infants with posture and movement dysfunction characterized by impairments in head and trunk orienting responses. The specific targeting of dynamic co-activation of trunk musculature in the STA protocol produced better performance than the nonfocused activation of trunk musculature that was inherently present in the play activities used in the PIP protocol group. Even with a small sample size and short intervention duration, the researchers of this study provide statistical evidence that an operationally defined NDT-based trunk protocol may be an effective method of improving independent functional movement for infants with posture and movement dysfunction during the first year after birth.

Future research on the psychosocial ramifications of improved motor gains should include outcome variables for evaluating the relationship between improved function and other enablement dimensions, eg, family functioning and social participation. Harris,[23] Ketelaar et al,[24] and Jansen et al[25] hypothesized that improvement in motor performance may increase family functioning and societal participation.

Homogenous Participants

As described previously, one common methodological problem in infant studies of the effects of pediatric therapy[6-13] has been the failure to use a homogenous group of participants. In all five infant studies,[6-13] participants were selected with "high risk" medical diagnoses but without documented developmental impairments. The confounding variable of heterogeneity of participants may have contributed to nonsignificant results because the researchers may have been testing the efficacy of pediatric therapy on samples containing a majority of typically developing infants. The current study included only infants identified with homogenous postural and movement impairments and gross motor functional activity limitations.

The NDT approach hypothesizes that functional activity limitations can be linked to specific system impairments that are targeted during intervention.[16] Infants in this study demonstrated gross motor delay with posture and movement dysfunction that was specifically characterized by impairments in orienting responses of the head and trunk.

Operationally Defined Protocol

The operationally defined NDT-based STA protocol used in this study specifically addressed the role of dynamic co-activation of trunk musculature in orienting responses as they relate to functional skills in infants. The use of an operationally defined protocol that is linked to a specific impairment common to a group of infants with posture and movement dysfunction can be used to examine the validity of one assumption of the NDT approach: "effective and ineffective posture and movement serve as a link between the individual's functions and the system impairments."[16(p.98)]

The researchers who conducted the current study illustrated that a specifically defined NDT-based STA protocol can be taught to multiple professionals within the context of a continuing education environment. In addition, we believe this operationally defined protocol will reduce variability and allow replication of the study, important for continuing investigation of the NDT approach for infants.

The PIP protocol was used to control for attention, maturation, and environment. Although it inherently included motor activities, the PIP protocol was not designed to be equivalent to the STA protocol with respect to individualized trunk activities. Future research to evaluate the effects of a generalized play intervention including trunk focused play activities delivered by early interventionists and compared to an individualized trunk activation intervention delivered by NDT infant-trained therapists could address other aspects of EI service models.

Frequency of Intervention

The authors suggest that a short-duration, high-frequency NDT-based STA protocol intervention may produce clinically important changes for infants of ages 4 to 12 months with posture and movement dysfunction. Piper's 1990 review of the literature[26] indicated that physical therapy was more effective in promoting motor milestone development if administered at least twice weekly. Results of improved motor function with higher frequency NDT intervention for children with CP are corroborated by other researchers, eg, Mayo,[27] Bower and McLellan,[28] Bower et al,[29,30] Mahoney et al,[31] Trahan and Malouin,[32] and Tsorlakis et al.[33] Continued research examining the optimal intervention frequency and duration for infants with posture and movement dysfunction is recommended.

Routine Therapeutic Intervention

Throughout the duration of the study, the infants in both groups continued to receive ongoing EI therapeutic services. Both groups improved their GMFM mean group scores after the study intervention of 10 hours over a 15-day period. The STA protocol group gained more with the study intervention than the PIP group, given identical parameters of attention, maturation, and environment. The investigators in this study suggest that increased frequency of intervention over frequencies commonly present in current EI programs may better facilitate maximal progress and realization of potential for infants with posture and movement dysfunction. The observed statistically significant increase in GMFM scores after implementation of the dynamic co-activation of trunk musculature protocol in the STA intervention group cautiously suggests a maximized return on investment of resources for the infants, therapists, and funding agencies. With return to routine EI therapeutic services and withdrawal of the study interventions during the 3-week postintervention period, both groups demonstrated a slight negative trend indicating the possible inability of routine ongoing EI therapeutic services to maintain or improve recent gains in gross motor skills. Implications from this study point to the need for continued research examining both the frequency and type of intervention critical for infants with posture and movement dysfunction, eg, comparisons between direct therapy and consultative service delivery models and intervention frequency.

Retention of Gains

The within-group mean GMFM scores from posttest to 3-week FU provide evidence that gains made from a short, intensive NDT-based STA protocol can be maintained for the short term. Although skills are maintained, continued specific sequential trunk activation intervention is likely needed to promote further progress.

The wide variance in both groups of GMFM change scores posttest to 3-week FU generates questions regarding the infants' underlying body system impairments and subsequent functional gross motor limitations. Participants whose scores declined in the postintervention to 3-week FU period seemed to have motor limitations strongly influenced by sensory processing dysfunction. Although sensory testing was not conducted, numerous sensory defensive behaviors were observed during intervention. Future research should include discriminatory measures to differentiate infants with and without sensory processing dysfunction. Such identification of infants with sensory processing dysfunction may help clarify which infants will better retain gains made with the NDT-based STA protocol intervention.

In future research, the retention of gains should be assessed over a longer FU period than in the current study. Varying periods of intervention or no intervention is recommended to discover which schedule(s) yield maximal gains and retention effects for specific disabilities and impairments.

Instrument and Rater Reliability

The evaluative tool used in this study was validated for infants with posture and movement dysfunction (ie, CP) to measure change over time as a result of intervention. Studies reported earlier, ie, Goodman et al,[6,9] Piper et al,[7,8] Weindling et al,[11] and Salokorpi et al[12,13] used outcome measures that were standardized on typically developing populations. The use of appropriate outcome instruments with reported reliability and validity for specific populations and interrater reliability of examiners masked to group assignment and study intent are critical for addressing the question of intervention efficacy in specialized populations with posture and movement dysfunction.

Policy Implications

Possible challenges to EI policy related to service delivery models and frequency of intervention are generated by this study. Scrutiny must be given to the national trend of using a generalized play approach delivered by early interventionists with therapist consultation for motor intervention services to infants with posture and movement dysfunction. The researchers of this study suggest that focused

The balance between using generalized interventionists and licensed professionals with subspecialty training in infant development and movement science within the EI service delivery model is in need of further evaluation. Continued research is essential to define the quantity of intervention, the specific intervention protocol, and the skills of the provider for optimal and cost-effective outcomes for infants intervention specifically matched to identified impairments andwith posture and movement dysfunction. delivered by a NDT-infant-trained therapist can produce a significantly higher level of motor skill improvement compared with nonfocused intervention delivered by a more generally trained interventionist when provided at the same increased frequency. A generalized play approach may have benefits in other areas, ie, cognition, social; however, this may not be true for motor skills.

Limitations

Four primary features of the study limiting the generalizability of results are (1) small sample size, low power, and purposive convenience sampling, (2) rater masked to group assignment but not to study intent, (3) outside routine EI therapeutic services tracked but not controlled, and (4) infant cognition not tested. The small sample size in this study was a result of the referral policies of the specific locale (eg, economics; Health Insurance Portability and Accountability Act) and the 44% to 50% attrition rate. The primary reason for attrition in the PIP group was that parents were interested in participating in the study only if their infants were in the STA treatment group. No measure directly assessed the infants' cognitive level, although it is clinically assumed to influence the infants' motivation and ability to learn. Future development of a motor-free cognitive tool for infants' ages 4 to 12 months is needed. Infant cognitive abilities may then be used to more equitably stratify groups before randomization.

CONCLUSION

A short-duration, high-frequency NDT-based infant protocol focused on dynamic co-activation of trunk flexors and extensors and specifically sequenced trunk movements significantly improved gross motor function in infants with posture and movement dysfunction compared to a nonindividualized Parent-Infant-Play protocol that only indirectly addressed the trunk. These motor gains were maintained for 3 weeks. Providing attention through guided, enriched play activities and interaction with social support did not significantly improve infant motor performance during the same time period. The infants with posture and movement dysfunction made gains that seemed to be the result of the short-duration, high-frequency, sequential trunk activation interventions provided by pediatric therapists specializing in the NDT approach for infants.

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APPENDIX A

NDT-Based Infant Sequenced Trunk Activation Treatment Protocol Within the NDT Problem-Solving Assessment and Intervention Planning

The STA treatment protocol used in the study was taught to NDT-trained pediatric therapists in a 3-week advanced specialization course for NDT-based infant treatment. Study intervention sessions occurred during treatment practicums, in the second and third weeks of the course. The course faculty supervised the course participant-therapists during the 10 one-hour treatment practicum sessions. The course curriculum consisted of didactic, practical, experiential, and problem solving activities totaling 103.75 contact hours.

Each individualized intervention plan was developed to meet the functional goals collaboratively established by the parents, course participant-therapists, and course faculty from infant and parent needs and concerns. The functional goals addressed transitional mobility skills (eg, rolling, prone to sitting, sitting to quadruped to sitting, quadruped to standing) within a variety of positions, as well as interaction skills with environment and caregiver. The functional goals were analyzed to identify the following essential posture and movement components†:

* Head orientation toward vertical

* Eyes horizontal

* Appropriate base of support for functional activity

* Trunk alignment over appropriate base of support

* Neutral pelvis

* Actively balanced trunk musculature with weight shift

* Trunk elongation on the weight-bearing side

Appropriate orienting of head and body parts to the support surface for maximal contact and proprioceptive sensory input.

The essential posture and movement components that were missing, delayed, or atypical for the identified functional goal were targeted. Dynamic control by the infant of the targeted posture and movement components was then facilitated, repeated, and embedded in the context of meaningful appropriate play activities.

When intervening with the infant during a transitional activity identified in the functional goal(s) and addressing the targeted missing, delayed, or atypical posture and movement components, the course participant-therapist followed a fluid sequence:

1. Systems Review: Review both positive and negative effects of relevant systems on the specifically selected functional activity and adapt the intervention plan to capitalize or adjust for system impairment. Systems to be considered are: the auditory, visual, respiratory, cardiovascular, gastrointestinal, integumentary, nervous (state control, arousal), sensory, musculoskeletal, and neuromuscular systems.

2. Engage: Build trust. Wait for the infant to actively participate in reciprocal interactions before touching the infant. The infant may actively participate by giving eye contact, vocalizing, or physically touching the therapist.

3. Prepare: Address range of motion, level of alertness and arousal, and sufficient postural tone needed for the infant to activate the targeted posture and movement components.

4. Align: Make physical and environmental adjustments to align body joints and body mass over an appropriate base of support for the targeted posture and movement components.

5. Activate: With clear intention, elicit dynamic co-activation of flexors and extensors of the head and trunk musculature and facilitate weight shifts into the base of support. Weight shifts for dynamic trunk activation are facilitated in a specific sequence of planes of trunk movement: sagittal first, frontal second, and transverse last.

6. Repetition: Provide multiple opportunities, within each intervention session, for repetitions of posture and movement components of selected functional goals within the context of an appropriate play or daily life activity. Physical assistance must be graded to allow infant to gradually achieve independent motor skills.

7. Home repetition: Integrate selected, targeted posture and movement components into function at home. Use activities of daily living, such as, carrying, picking up, putting down, and diapering for multiple opportunities to strengthen, integrate, and generalize posture and movement components into functional activities in home environment.

The STA protocol intervention was applied specifically to the "activate" portion of each activity sequence. The STA protocol intervention is focused on facilitated dynamic co-activation of trunk flexors and extensors and specifically sequenced trunk movements during transition activities and consists of the following: (1) facilitation of dynamic co-activation of trunk flexors and extensors in the sagittal plane that is adequate to the demands of a specific functional activity, (2) facilitation of active weight shifts in the frontal plane to produce "elongation on the weight-bearing side," while maintaining the appropriate dynamic co-activation of trunk flexors and extensors,[16] and (3) facilitation of active functional trunk rotation, while maintaining dynamic co-activation of trunk flexors and extensors and active trunk elongation of the weight-bearing side, ie, transverse plane. Functional trunk rotation is integral to the development of equilibrium behaviors for variability in motor responses[20] and higher level balance.[16(p.41)] Functional trunk rotation is facilitated as appropriate for the age of the infant and the specific functional skill within the chosen activity.

Each step in the STA protocol creates the base needed for the next step in the sequence. Intervention that incorporates the STA protocol produces dynamic trunk co-activation in sequenced trunk movements adequate for the demands of transitional activities. In an infant-led session, the individualized application of the protocol may seem different for each infant and within a session depending on the functional activity of interest to the infant.‡ Cited Here...

APPENDIX B

Parent-Infant Playgroup Protocol

A licensed Child Life Specialists coordinated the PIP group that met for 10 one-hour sessions over a period of 15 days. A graduate psychology student, who was a mother of a child with CP, and an aerobics instructor who specialized in postpartum exercises, assisted the Child Life Specialist in the intervention activities for the parents and infants.

The parents delivered the enriched play activities, with guidance from the Child Life Specialist for 30 minutes at each of the 10 intervention sessions (Table 3). The play activities, selected from *Gymboree, A Parent's Guide to Baby Play*,[21] targeted various areas of development, such as: visual, tactile, auditory, social, cognitive, emotional, and communication.

Table 3

The psychology graduate student planned and led the discussion sessions. The topics she included during the six 30-minute blocks were (1) importance of self care; (2) ways to feel empowered; (3) Elizabeth Kubeler-Ross's stages of grieving, particularly in relation to their infant's disability; (4) coping skills for managing an infant with a disability; and (5) sharing their "stories."

The postpartum aerobic instructor led the parents in a comfortably paced, general body fitness routine that included their infants. Each session involved continuous activity for 30 minutes, during four of the 10 group sessions. The instructor demonstrated ways to pick-up and put down the infants with appropriate body mechanics to reduce the risk of back injury and to tone the abdominal muscles of the adult. She demonstrated ways to push the infant in the stroller to perform gentle body muscle stretching and strengthening activities. The instructor incorporated holding, lifting, and moving the infant for adult upper and lower body strengthening activities during play times. Cited Here...

*NDT-based STA protocol with clinical example is available by request to the first author. Cited Here...

†The category of effective and ineffective posture and movement function components is depicted in "The NDT Enablement Classification of Health and Disability," Table 2.1, page 82, found in *Neuro-Developmental Treatment Approach: Theoretical Foundations and Principles of Clinical Practice* by Howle (2002).[16] Cited Here...

‡NDT-based STA protocol with clinical example is available by request to the first author. Cited Here...

Keywords:

developmental disabilities; human movement system; infant; infant development; motor skills; physical therapy; postural equilibrium

How Does Neurological Reorganization Address Attachment Spectrum Disorders?

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People from all walks of life and cultural backgrounds are vulnerable to developing attachment spectrum disorders. Individuals with diagnoses such as reactive attachment disorder and oppositional defiance disorder fall onto this spectrum. Any form of an attachment spectrum disorder interferes with an individual's ability to form appropriate relationships and feel safe, secure, and worthy to be in the world. Behaviors observed include poor peer relationships, hyper vigilance, anxiety, destruction to self or others, superficially engaging phoniness, indiscriminate affection with strangers, extreme measures to gain and exert control, lying, extreme anger, clinginess, manipulation, violence, poor impulse control, lack of conscience, poor causal thinking, abnormal eating patterns, lack of eye contact except when lying, cruelty to animals, and learning delays or disabilities. [Note: symptoms may present differently in a very young child.] Neurological reorganization addresses and resolves the underlying neurological condition, so that the effected individual can form lasting and strong relationships, and feel safe, secure, and worthy to be in the world.

Attachment spectrum disorders primarily affect the part of the brain called the pons. The pons typically develops between one to five months of age and is responsible for all vital, life-preserving function, including respiration, heart rate, and other necessities for survival. It identifies threats to our safety and regulates the response to those threats. Because the pons develops in very young infants, it has no spoken language and is reliant on movement, reflex, and sensory experience.

Normal infants complete a specific sequence of developmental tasks to establish healthy pons function, including crawling on the belly and whole body reflexive patterns. Visually, a pons-level infant loves to gaze at the outline of faces and into another human's eyes. Gazing into another's eyes, especially the biological mother's, establishes a sense of safety and security. Indeed, babies' initial vision extends from mother's breast to mother's eyes, because this function is so critical. Pons-level infants develop horizontal eye tracking so that they can track their caregivers coming and going from their environment. In both terms of hearing and sensory perception, a pons-level infant identifies threats. Any loud or threatening sound, such as a dog barking, causes the baby to cry for help. Similarly, this baby feels extremes of heat, cold, hunger, and pain and, upon feeling any of those, cries for help. No normal adult can resist a pons-level infant's cry as it says, "Help me! Help me! I'm dying!" A pons-level infant perceives the world in terms of black and white: "I'm not with Mom, I'm going to die; I'm hungry, I'm going to die; I'm cold, I'm going to die." Crying is the way this baby exerts control over her environment and is assured by her primary caregiver that her needs will be met. This assurance that her needs will be met when she cries is also how she begins to feel safe, secure, and bonded. To insure healthy pons function, it is critical that an infant completes this entire developmental sequence. Any gap in the developmental sequence will result in impaired neurology and behavioral, emotional, academic, or motor problems.

Pons-level dysfunction occurs when the infant's needs are not adequately met and/or her ability to complete developmental movements is restricted. (Developmental movements are the set of activities infants automatically do to grow neural connections and acquire functional neurology.) An infant's inability to grow these connections and develop healthy pons function results from a number of issues, most notably a separation from her biological mother. At this point of development, the infant believes that she and her mother are a single unit. Any separation, whether as a result of maternal illness, hospitalization, neglect, adoption, or long working hours, triggers the "Help me, help me, I'm dying!" stress response in the infant. This stress response also occurs as a result of infant illness, injury, trauma, abuse, or cultural interference that limits the infant's ability to complete developmental movements, such as excessive time spent in walkers, jumpers, bouncy seats, carriers, car seats, or other containment devices. The pons regulates response to threats and, when stressed, high levels of neurochemicals related to the "fight or flight" response are released for a prolonged period of time. The infant's neurology accommodates this toxic level of stress hormones; her brain literally behaves as if it is threatened at all times. Consequently, even if the individual's needs are met, normal function does not occur, because the correct neural pathways to support healthy pons function are absent. No amount of nurturing will lead to normal neurological function due to this faulty wiring. The only way for healthy pons function to occur is to directly stimulate the pons and facilitate healthy neurological development.

A spectrum of behavioral and emotional issues characterize pons dysfunction. Recognition of threats and dangers, a perpetual state of fear, and diminished pain perception are the three largest hallmarks.

One of the most critical purposes of the pons is the recognition of external threats and dangers. Pons dysfunction skews this recognition, so that the individual cannot accurately identify threats in his external environment. Individuals with this issue often behave recklessly. They cause deliberate harm to themselves without a sense of the risk involved. For instance, children with this issue take inappropriate risks, such as riding their bicycle off a steep jump or leaping off the roof, and, when confronted with the danger of the situation, respond nonchalantly with statements such as, "It's not a big deal," or, "But I didn't get hurt; stop worrying". A skewed recognition of threats and dangers has emotional and social ramifications as well, including social promiscuity. The socially promiscuous individual tries to win the favor and attention of almost everyone she meets, as she fails to discriminate between her relationships with family members and those outside of the intimate circle. She may share personal information with strangers or develop superficially close relationships immediately. Due to the inability to appropriately recognize danger, an individual may assign it to an innocuous source and feel isolated from those around him. Feelings of loneliness, despair, and abandonment predominate. Pons emotions develop pre-verbally, so there are no words an individual can use to adequately express them. This contributes to a sense that no one understands. The inability to verbalize her emotions erects another barrier between her and the outside world. Sometimes individuals release these emotions through rages which tend to be extreme and, possibly, violent. Inappropriate recognition of threats and dangers disconnects and isolates the individual from those around him and risks incalculable physical harm.

The pons controls the internal, "Help me! Help me! I'm dying!" response to stressful situations. An individual with this issue's homeostasis is constant life or death struggle, a perpetual state of life-threatening fear. This fear expresses itself in an array of behaviors. Individuals attempt to exert control over their environment to mitigate this fear. Feeling at a loss, the individual attempts to gain as much control as possible. This is the child who tries to control his environment and those around him. He creates his own set of arbitrary rules, which he expects others to follow. If those around him fail to do so, he becomes angry, although the anger often remains unexpressed. Consequently, the individual's belief that the world is hostile and unsupportive is confirmed and his sense of security further deteriorates. This behavior appears incredibly manipulative to those around him. Control can also be self-directed, such as in the case of eating disorders. Additionally, this individual may be hyper-alert and anxious, behaving as if even the most innocuous situation is dangerous. Children with this dysfunction often cannot sleep alone or become hysterical when left with a caregiver other than a parent. Individuals may be clingy, never physically letting go of their caregiver. This individual perceives she is literally hanging on for dear life. The individual may need to know exactly what is going to happen in the future and is unable to cope with change. This dysfunction may also manifest as over attentiveness to the feelings and wishes of others. The individual may go out of her way to appease those around her; she has no sense of what those around her feel, so behaves conciliatory. Others may be angry or pleased, but, with no way of interpreting, she assumes the worst and does her best to prevent it. This appears as phoniness or superficial charm. Additionally, pons-level dysfunction impairs an individual's ability to receive and interpret love. The emotion of love requires a sense of safety and security which individuals lack due to their sense of perpetual fear. Life-threatening fear drives all emotional interactions.

The third major hallmark of pons-level dysfunction is diminished pain perception. Pain is our friend, telling us when an activity causes us harm and should cease. Additionally, pain teaches us empathy and compassion: if I don't feel the same way that you feel, what is there to stop me from laughing if you are hurt? It wouldn't hurt me, so I can't comprehend why it hurts you. Diminished pain perception can manifest as the individual who seriously injures herself without the injury causing any distress. For instance, this is the child who does not fuss when teething or who suffers an accident without appropriate crying. Parents say, "He's such a tough little toddler; he just gets right back up again," or, "He has bruises all over his body and doesn't remember how he got them." Diminished pain perception becomes self-directed as well. Individuals attempt to stimulate sensation through self-mutilation and extreme forms of sensory input, such as picking at scabs until they bleed, biting fingernails until they bleed, head banging, cutting, and stabbing themselves. When asked about these self-destructive behaviors, a common reply is, "I just wanted to feel something, anything at all." Because of this desire to stimulate sensation, individuals with diminished pain perception often create chaos in their environment. They wreck havoc, physically and/or emotionally, so that they feel something, however negative. This is the child who plays too rough with other children or animals, without comprehending that this causes pain or distress. This individual may also deliberately hurt an animal or other person and then laugh about it. If an individual's own sense of pain is hindered, he has nothing to which to compare another's pain; hence, it becomes amusing. This is one of the more dangerous characteristics of attachment and bonding disorders and easily leads to violence.

The net sum of these hallmarks is a profound sense of displacement and mistrust of the external world. Individuals lack sufficient means of receiving signals from the world or appropriately interpreting them. The individual may believe the world revolves around him or assign blame of any problems to those around him. Statements such as, "No one could get by without me," or "You're the one with the problem; I'm fine," are common. This individual only trusts his own experiences and, consequently, does not trust or believe the words and actions of others. Even as a caregiver assures the individual of her benign intent, he views that through a lens of mistrust, keeping him isolated.

When these foundational level deficits remain, the individual's emotional growth is stunted and, when taken to an extreme, results in psychopathic behavior. Because advanced neurology is built upon the successful completion of more basic levels, dysfunction in the foundational levels halts healthy emotional growth. All that develops from that point forth is predicated on a shaky foundation, much as a house built on a poor foundation. This leads to the other characteristics of attachment spectrum disorders, such as learning disabilities and difficulty with causal thinking. In extreme situations, all function shuts down, resulting in sociopaths. These are the withdrawn individuals, who fail to form any bonds. These individuals are unmitigated by conscience, or the ability to make good decisions even when unmonitored; they feel nothing at all and lack sensation of the external world. Because of this, these individuals go to extremes to elicit sensation, such as luring younger children and hurting them or killing pets. This behavior escalates to violent crime. As a convicted serial killer said, "I don't have any feelings about what I did, I don't remember ever having any feelings."

Neurological reorganization addresses the underlying structural dysfunction so that normal function can occur. We provide a program of activities that stimulates the damaged or absent neural pathways to grow. Once those are in place, normal function can occur and the constellation of emotional and behavioral problems subside. The individual gains the capacity to form appropriate bonds and relationships. He gains the tools to trust those around him. He identifies and respects his emotional and physical boundaries, which, in turn, allows him to respect others. His behavior adjusts to become more appropriate to his current circumstances. Cortical psychiatric care becomes effective in dealing with the consequences of appropriately recognizing threats and dangers, diminished pain perception, and a state of fear.

Bonding and attachment disorders can be debilitating to those who experience them and to those individuals' loved ones. Due to the neurological basis of the disorders, traditional therapies are largely unsuccessful. Stimulation of the injured part of the brain and repetition of neurological development allows healthy function to occur. While the individual must address those lingering emotions, he is now free to form appropriate relationships. As the mother of such a child remarked, "He still has much to learn about the emotions that were so long locked away from him, but now he has the ability to be a healthy and happy child."

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COMPARISON BETWEEN THE EFFECT OF NEURODEVELOPMENTAL TREATMENT AND SENSORY INTEGRATION THERAPY ON GROSS MOTOR FUNCTION IN CHILDREN WITH CEREBRAL PALSY

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Abstract

Objective

This study was planned to compare the effects of neurodevelopmental treatment and sensory integration therapy on gross motor function in children with cerebral palsy

Materials & Methods

Twenty two children with spastic CP were randomly divided into two groups. Sensory integrative therapy was given to the first group (n=11), and neurodevelopmental treatment was given to the second group (n=11). All children were evaluated with GMFM-88. Treatment was scheduled for three - one hour sessions per week for 3 months.

Results

Twenty two children with spastic CP (11 diplegia and 11 quadriplegia) participated in this study. When two groups were compared, a significant difference was found in lying and rolling (P=0.003), sitting (0.009), crawling and kneeling (0.02) and standing ability (P=0.04). But there was no significant difference in walking, running, and jumping abilities between the two groups (0.417). Paired t-tests revealed a significant difference between pre and post test results, with increases in scores of lying and rolling, sitting, crawling and kneeling, standing in sensory integration therapy (SIT) and neurodevelopmental treatment (NDT) approaches.

Conclusion

Neurodevelopmental treatment and sensory integration therapy improved gross motor function in children with cerebral palsy in four dimensions (lying and rolling, sitting, crawling and kneeling, standing). However, walking, running and jumping did not significantly improve.

Keywords: Cerebral palsy, Children, Neurodevelopmental treatment, Gross motor function, Sensory integration therapy

Introduction

Cerebral palsy (CP) is described a group of permanent disorders of the development of movement and posture, causing activity limitations, which are attributed to nonprogressive disturbances that occurred in the developing fetal or infant brain. The motor disorder of cerebral palsy is often accompanied by disturbances of sensation, perception, cognition, communication and behaviour, by epilepsy, and by secondary musculoskeletal problems (1, 2). Cp is clinically classified as spastic, athetoid, spastic, and hypotonic (3). The primary problem in CP is gross motor dysfunction (4). Also, the severity of limitation in gross motor function among children with CP, the most common physical disability, is highly variable (5). Occupational therapy in children with CP is performed to avoid abnormal muscle tone and posture, treat muscle and joint deformities, and reduce motor and sensory disorders (6).

Currently, several approaches are used for the treatment of children with CP, which show promising effects on improving motor and functional activities. Among these approaches, the neurodevelopmental treatment (7, 8, 9) and sensory integration therapy (10, 11, 12, 13) are the pioneers for serving children with CP in the field of occupational therapy.

The neurodevelopmental treatment approach for CP is the most widespread and clinically accepted to target the central nervous and neuromuscular systems and 'teaches' the brain to improve motor performance skills and to achieve 'as near normal function as possible', in view of the specific lesion in the central nervous system. The main purpose of this approach is to correct abnormal postural tone and to facilitate more normal movement patterns for performing performance skills (14, 15). On the other hand, sensory integration therapy (SIT) is one of the rehabilitative approaches that was originally developed by A. Jean Ayres in the 1970s. The principles of SIT are used by occupational therapists in developing treatment approaches for children with sensory processing difficulties, including CP. The SIT approach attempts to facilitate the normal development and improves the child ability to process and integrate sensory information. It is proposed that this will allow improved functional capabilities in motor function (6).

Some studies have shown that the NDT approach is effective in improving measures of motor performance in children with CP, especially in gross motor ability, postural control, and stability (16, 17, 18, 19, 20). In contrast, other investigators have found that the SIT is one of the methods for promoting motor activity skills and improving measures of motor performance in children with CP because a child with cerebral palsy may experience sensory integration dysfunction as a result of central nervous system damage, or sensory integration dysfunction might develop secondary to the limited sensory experiences that these children have as a result of their limited motor abilities (6, 21, 22). So, children with cerebral palsy frequently receive NDT and SID from occupational therapists to reduce the problems of impaired movement and coordination. However, the comparison between these two methods has not yet been done. Therefore, this study was conducted to compare the effect of the sensory integration therapy and neurodevelopmental treatment on gross motor function of the children with CP.

Materials & Methods

Participants

Twenty two children with spastic CP were selected from a population of individuals with CP who had been followed up at Baqiyatallah Hospital. Inclusion criteria were as follows: a diagnosis of spastic CP (patient's diagnosis of CP confirmed by an expert pediatrician and a neurologist), no other severe abnormalities such as seizure, no participation in other therapeutic programs except for occupational therapy, age between 2 and 6 years, and referral to the occupational therapy clinic of the children with disabilities, Baqiyatallah Hospital, for a 12-week course of treatment. Our exclusion criteria were (a) receipt of medical procedures likely to affect motor function such as botulinum toxin injections, (b) orthopedic remedial surgery, (c) mental retardation or learning disability

Instrumentation

GMFM

Gross Motor Function Measure (GMFM) was used to evaluate the gross motor function of the patients. GMFM is the first evaluative measure of motor function designed for quantifying changes in the gross motor abilities of children with cerebral palsy (22). The measure is widely used internationally, and is now the standard outcome assessment tool for clinical intervention in cerebral palsy. In children with CP, GMFM has been shown to be sensitive to changes during the periods of therapy (24, 25, 26). This clinical measure consists of 88 items grouped into 5 gross motor function dimensions; lying and rolling (17 items), sitting (20 items), crawling and kneeling (14 items), standing (13 items), and walking, running, and jumping (24 items). The 88 items of the GMFM are measured by child observation and scored on a 4-point ordinal scale (0=does not initiate, 1=initiates <10% of activity, 2=partially completes 10% to <100%

of activity, and 3=completes activity). Scores for each dimension are expressed as a percentage of the maximum score for that dimension. The total score is obtained by averaging the percentage scores across the 5 dimensions. The entire GMFM is administered without mobility aids or orthoses (27). Also, In Iran, this test has been used to assess gross motor function in children with cerebral palsy (6, 37). There is evidence to back up the reliability and validity of GMFM scores (23, 27).

NDT

The NDT approach for CP is the most widespread and clinically accepted to target the central nervous and neuromuscular systems and teaches the brain to improve motor performance skills and to achieve as near normal function as possible (7, 8, 9). This program includes passive stretching of lower limb muscles (e.g. hamstrings, gastrosoleus), followed by techniques of reducing spasticity and facilitating more normal patterns of movements while working on motor functions. These treatment outcomes are supposed to be achieved through physical handling of the child during movement, giving the child more normal sensorimotor experiences. As the child gains postural control, the therapist gradually withdraws support. Handling techniques and treatment activities undergo continual changes as they are adapted to the responses of a particular child (28).

SIT

SIT is a treatment approach that was originally developed by Jean Ayres (10). It helps children with CP to achieve their optimal level of sensory and motor functioning (10, 11, 13). It is typically given by an occupational therapist with training and expertise in sensory integration. SIT is an active therapy, and the activities usually involve visual-motor co-ordination training, ocular-pursuit training, moving ball and pegboard activities, turning left and right side and awareness of the body parts through touch (6, 21, 22). It is a process occurring in the brain that enables children to make sense of the world by receiving, registering, modulating, organizing and interpreting the information that comes to their brains from their senses. SIT helps to overcome problems experienced by many children in absorbing and processing sensory information. Encouraging these abilities ultimately improves balance and steady movement by training (29, 30). Also, in a research by shamsoddini and hollisaz, the result showed that SIT intervention had a significantly positive effect on gross motor function in children with diplegic spastic CP (6).

Procedures

Ethical approval was granted to the study and informed written consents were signed by all parents. Gross motor abilities of the subjects were first evaluated in five dimensions (Lying and rolling; Sitting; Crawling and kneeling; Standing; Walking, running and jumping). Participants were then randomly divided into two experimental groups. There were 11 children in each group. In one group, children were treated by NDT and in the other group, children received SIT. Duration of the treatment for the two groups were three days a week for 3 months, each session being 1.5 hour and was then re-evaluated by the GMFM again after the interventions. All of patients were treated by occupational therapists with at least 8 years of experience. The treatment was conducted in one rehabilitation centre for all participants in the two groups.

Statistical analysis was performed with SPSS (version 17). Normal distribution of variables was assessed with the Kolmogrov-smirnov test. Independent sample t-test was used for comparison of scores between two groups. The pre and post intervention mean scores for each group were analyzed using a paired-sample t-test, to determine whether there were any significant differences. P-values less than 0.05 were considered statistically significant.

Results

A total of 22 children based on the inclusion criteria were enrolled in the study and completed the course of the treatment for 3 months. Information on sample characteristics including sex, type and distribution of CP are listed in Table 1. The SIT and the NDT group had a mean age of 3.6 years and 3.1 years, respectively. Pre- and post-treatment mean, standard deviation, minimum and maximum scores for the GMFM-88 are given in Table 2.

The independent simple t-test showed significant improvements in GMFM-88 scores in both groups in lying and rolling (P=0.003), sitting (P=0.009), crawling and kneeling (P=0.02) and standing positions following SIT and NDT (P=0.04). However, there were no significant improvements in walking, running and jumping (P=0.417) (Table 3). The paired t-test, used for comparing the values before and after intervention in the SIT group, revealed significant changes in GMFM-88 scores of lying and rolling, sitting, crawling and kneeling, and standing ($P > 0.05$). However, no significant difference was observed in walking, running and jumping abilities before and after SIT intervention ($P > 0.05$) (Table 4).

The Student t-test revealed significant changes in children who received NDT in GMFM-88 scores of lying and rolling, sitting, crawling and kneeling, standing, and walking, running and jumping before and after NDT intervention ($P < 0.05$) (Table 4).

Table 1. Characteristics of the samples

Group	n	Male	Female	Diplegia		Quadriplegia	
				Male	Female	Male	Female
SIT	11	6	5	3	2	3	3
NDT	11	8	3	4	2	4	1
Total	22	14	8	7	4	7	4

Table 2. Descriptive statistics in the SIT and NDT groups

Group	Assessment	GMFM-88*			
		Mean	SD**	Min***	Max****
SIT	After treatment	102.1	10.7	75	122
	Before treatment	117.6	9.1	103	148
NDT	After treatment	99.6	9.6	81	120
	Before treatment	102.7	8.9	104	152

GMFM*, Gross Motor Function Measure; SD**, Standard Deviation; Min***, Minimum Max****, Maximum

Table 3. Comparison of differences between groups

	Group	Mean ± SD		p
		Before	After	
lying and rolling	SIT	39±3.3	48±4.1	0.003
	NDT	35±3.6	47±3.9	
sitting	SIT	43±4.1	52±4.3	0.009
	NDT	46±4.2	55±4.7	
crawling and kneeling	SIT	20±2.3	26±2.5	0.02
	NDT	22±2.5	28±2.8	
standing	SIT	15±1.7	18±2.1	0.04
	NDT	17±1.9	31±3.2	
walking and running and jumping	SIT	29±2.8	31±2.3	0.417
	NDT	31±2.9	32±3.1	

Table 4. Pre and Post GMFM-88 scores between the NDT and SIT groups

		Lying & rolling	Sitting	Crawling & kneeling	Standing	Walking & running & jumping
GMFM scores in SIT	Before	39±3.3*	43±4.1	20±2.3	15±1.7	29±2.8
	After	48±4.1	52±4.3	26±2.5	18±2.1	31±2.3
P Value		0.000	0.001	0.003	0.001	0.842
GMFM scores in NDT	Before	35±3.6	46±4.2	22±2.5	17±1.9	31±2.9
	After	47±3.9	55±4.7	28±2.8	31±3.2	32±3.1
P Value		0.000	0.000	0.004	0.002	0.03

*Value is Means ± Standard Deviation

Discussion

Improvement of gross motor function is one of the most important aims of treating children with CP. Mainly, the aim of SIT and NDT is also to promote gross motor function for children with cerebral palsy. In this study, two interventions, which were administered for 3 months in children with spasticity - distribution of diplegia and quadriplegia- significantly improved their gross motor function as measured with the GMFM-88.

To the best of our knowledge, this is the first study that has compared neurodevelopmental treatment and sensory integration therapy on gross motor function of children with cerebral palsy. Various occupational therapy methods have been applied to obtain normal motor development, to prevent postural abnormalities, sensory defenses, gross motor dysfunction and deformities and to increase functional capacity in children with cerebral palsy (6, 16, 19, 21, 30).

According to the results, after comparing the two groups of children with CP for gross motor function, four dimensions of gross motor function, i.e. lying and rolling, sitting, crawling and kneeling, and standing, significantly improved following sensory integration therapy and neurodevelopmental treatment. However, walking, running and jumping showed no significant improvement between two groups. In a research by Ketelaar et al., a significant difference was noticed in rolling and sitting and kneeling after neurodevelopmental intervention (32). These results were consistent with our study showing significant changes in lying and rolling, sitting, crawling and kneeling and standing after NDT intervention. In another study, Fetters and kluzik reported that use of neurodevelopmental approach for treating children with cp caused improvement of motor functions (33). To date, few studies have investigated the effect of SIT on gross motor function improvements in similar intervention periods (a few weeks). In a randomized controlled trial by Carlsen, individuals were assigned to either the control group (n=6) or the SIT group (n=10), which received 2 hours of therapy per week over 6 weeks. This intervention period is almost similar to that of our study. Similar to our study, the group that received SIT experienced a significantly better improvement in sitting and crawling abilities compared to the control group (34). In our study, comparison of the two methods and also pre and post-treatment scores of both types of treatments showed a significant improvement in gross motor function over the 3 months of treatment with SIT and NDT. However, this effect might be anticipated as SIT and NDT focus on preparing, practicing, and gaining new functional skills (35). Published literature shows that sensory integration therapy programs have been used to facilitate motor functions. Each type of treatment (SIT or NDT) might be expected to yield different changes in motor performance. The SIT approach tries to facilitate normal development and to improve the child's ability to process and integrate sensory information (visual, perceptual, proprioceptive, auditory, etc) (36). Furthermore, one important aspect of choosing the SIT approach is that the motivation of the child plays a crucial role in the selection of the activities (37). In our study, comparison between pre and post intervention values of walking, running and jumping showed no significant difference in NDT or SIT approaches (36). Also, in a before-after study by Akbari et al. in which gross motor function of the subjects was assessed using GMFM, the results showed that a functional therapy program might be effective in increasing gross motor function and improving daily activities in children with cerebral palsy (38).

In conclusion, this study showed that neuro-developmental treatment and sensory integration therapy improved gross motor function. Four dimensions of gross motor function, including lying and rolling, sitting, crawling and kneeling, and standing, significantly improved after intervention. However, walking, running and jumping did not improve significantly.

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Down Syndrome: Sensory Integration, Vestibular Stimulation and Neurodevelopmental Therapy Approaches for Children

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Abstract

Down Syndrome is a disability characterized by significant limitations both in intellectual functioning and in adaptive behavior as expressed in conceptual, social, and practical adaptive skills. There are various degrees of sensory integration dysfunctions in children with an intellectual disability. Sensory integration is the organization of sensory input for use. Function of learning depends on the child's ability to make use of sensory information in order to perceive sensory information from his environment, integrate this information and plan and form purposeful behavior. Sensory integrative intervention, vestibular stimulation, neurodevelopmental therapy approaches are effective methods used as occupational therapy/ physiotherapy interventions in separate or combined programs with educational, behavioral and pharmacological interventions in children with an intellectual disability.

Definition of Child with an intellectual disability

The Diagnostic and Statistical Manual (DSM-IV) (American Psychiatric Association 1994) and ICD-10

Classification of Mental and Behavioral Disorders (World Health Organization 2008) classify individuals with child with an intellectual disability according to the severity (mild, moderate, severe, profound, other and unspecified) of the impairment in intellectual functioning. The American Association on Intellectual and Developmental Disabilities (AAIDD) has defined an intellectual disability in a child as a disability characterized by significant limitations both in intellectual functioning and in adaptive behavior as expressed in conceptual, social, and practical adaptive skills, which originates before the age of 18 (AAIDD 2008). Adaptive behavior signifies the quality of daily performance in dealing with environmental needs. Adaptive behavior is the sum of many abilities in order to achieve community integration. In adaptive behavior impairments, dealing with social needs is very important for children with an intellectual disability. AAIDD has suggested a 3-step process of Diagnosis, Classification and System of Support for the importance of adaptive behavior with relation to children with an intellectual disability. In this system, there are ten adaptive areas considered critical to a diagnosis of a child with an intellectual disability: communication, self-care, home living, social skills, community use, self-direction, health and safety, functional academics, leisure and work. In defining children with an intellectual disability, if the individual has limitations in two or more adaptive areas and an intelligence quotient (IQ) of 70-75 or below and the age of onset is 18 or below, the individual can be diagnosed as a child with an intellectual disability (Lambert et al. 1993).

AAIDD (2008) has specified five assumptions essential to the application of the definition:

1. Limitations in present functioning must be considered within the context of community environments typical of the individual's age, peers and culture.
2. Valid assessment considers cultural and linguistic diversity as well as differences in communication, sensory, motor, and behavioral factors.
3. Within an individual, limitations often coexist with strengths.
4. An important purpose of describing limitations is to develop a profile of needed supports.
5. With appropriate personalized supports over a sustained period, the life functioning of the person with child with an intellectual disability generally will improve.

Normal Motor Development

Normal development of movement and function is essential to the child's motor control achievement and learning. Motor learning develops in stages. The child first learns a skill and generalizes it to other circumstances. Movement and posture are learned in a sensory state or environment. Physical activity is necessary for motor development. The infant should move actively to gain basic motor skills such as rolling, coming to a sitting position, crawling, standing and walking. The development of postural control in children occurs in stages to their ability to integrate sensory information. Between the ages of 1 and 3 the sense of sight is dominant; and it is a powerful sense for achieving and maintaining the orientation of the upright position. At these ages the proprioceptive system generates simple and incomplete information. Practice is needed for the somatosensorial system to utilize proprioceptive information effectively. Between the ages of 4 and 6 somatosensorial and vestibular input is greatly used. Between the ages of 7 and 10 responses similar to those of adults are observed. The fundamental source of postural stability in children and adults is somatosensorial. General movements and reflexes enable voluntary and adaptive motor control; postural control develops first and provides the basis for movement, and coordinated movement takes place (Woollacott and Shumway- Cook 1986, Martin 1989, Aubert 2008).

Factors affecting the ability of movement

Factors of the musculoskeletal system

Mechanic factors such as gravity, gravity line, base of support and centre of gravity affect the development of movement. Characteristic of the muscles in the musculoskeletal system, movement of joints, joint range, ligament range, and tension of muscles are important factors for the development of maximum performance. Achievement of postural control is significant for endurance against gravity and muscle strength (Martin 1989).

Neuromotor factors

There are two kinds of reflexes: primitive and postural reflexes. Primitive reflexes are spontaneous, stereotypical responses to a specific stimulus. Postural reflexes are seen throughout life, also called automatic reactions, variable responses to stimuli, and aim at keeping the head and body in an upright position. As the infant develops and gains greater control of movement against gravity, the primitive reflexes decrease as the postural or automàtic reactions appear. Postural reactions appear in the following order as reactions of righting, protective, and equilibrium. The aim of the righting reaction is to maintain the correct orientation of the head and body. Protective reactions are extremity reactions to rapid displacements of the body by horizontal or diagonal forces. Equilibrium reactions occur during the changing of the centre of gravity by the movement of the body or support surface (Martin 1989, Aubert 2008).

Milestones of gross and fine motor development

From one to two months, the infant begins to display a decrease in physiologic flexion along with an increase in active extension against gravity while in a prone position. Around three months, the infant shows more symmetry in alignment and movement of the body. Around the fourth month, the infant practices bilateral use of flexion and extension that facilitates strong symmetry. At four months, the infant gains control of the head. At six months, the baby has good control of the head and displays strong control against gravity. Between six and eight months, the infant is able to rolling supine to prone segmentally. At eight months, the infant can come to a sitting position without help. At nine months, the infant starts pulling to stand. Creeping has become the main means of mobility for the 9-10-month-old child. Between 12 and 18 months, the infant can walk independently (Aubert 2008). Fine motor development is characterized by the following milestones: The child gains the ability of raking, five months; palmar grasp, six months; radial digital prehension, nine months; inferior pincer prehension, eleven months and neat pincer prehension, twelve months. Though the order of the milestones in these developments is generally as such, cultural differences and the child's previous experiences may change this order. Due to other individual differences for example motivation, opportunity etc., the speed in gaining these abilities may also change (Martin 1989, Aubert 2008).

Down syndrome and neuromotor control

In children with Down syndrome, there have been a number of observed and measured motor characteristics such as hypotonicity, joint hypermobility, decrease in deep tendon reflexes, maintenance of primitive reflexes, and a delay in the appearance of reaction timing and equilibrium reactions that may have contributed to delayed development. Various studies have shown that children with Down syndrome generally have deficits in eyehand coordination, laterality, speed, reaction timing, equilibrium and visual motor control (Henderson et al. 1981, Kerr and Blais 1985, Shumway-Cook and Woollacott 1985, Connoly and Michael 1986, Woollacott and Shumway-Cook 1986, Haley 1987, Stratford and Ching 1989, Dyer et al. 1990, Uyanik et al. 2001, Jobling and Virji-Babul 2004, N. Virji-Babul et al. 2006).

In children with Down syndrome, delays in postural reactions take place with the delays in motor development. Therefore, it is essential that therapeutic programs which increase the stimulation of postural reactions are utilized in the intervention program. Specifically, some children with Down syndrome need to develop strategies in order to eradicate useless sensory inputs. The formation of postural synergies and sensory inputs through integration is important in the therapeutic approach (Haley 1986). For the maintenance of stability, rapid-automatic postural responses should occur. In children with Down syndrome, dysfunction of stereognosis and decrease in motor skills are also related to hypotonia. Hypotonicity disrupts the feedback mechanism which enables the perception of the position of the body in space, and plays a role in the voluntary control of muscles, and as a result body posture and the quality of movement are affected (Woollacott and Shumway-Cook 1986). Due to the develop child with an intellectual disability of the cerebellum and the brainstem, coordination and timing components of motor control are affected (Seyfort and Spreen 1979). These dysfunctions observed in children with Down syndrome may also continue after preschool and adolescence periods. The occurrence of balance and coordination problems in these children supports the view that individual therapy may be useful not only during preschool period but also during all adolescent life (Connoly and Michael 1986, Moni and Jobling 2000).

Sensory Integration Theory

Sensory integration is "the organization of sensory input for use" (Ayres 1979). The term sensory integration which signifies a neurological process was first developed by Ayres. This process enables the spatial-temporal usage of the sensory information the individual gets from his body and environment and the perception, interpretation, and integration of information in order to plan and form organized motor behavior. According to this theory, mild and moderate problems in learning are related to motor in coordination and weak sensory process (Ayres 1972a, Ayres 1972c, Bundy and Fisher 1992, Fisher and Bundy 1992, Scheerer 1997).

Sensory integration theory is based on the view that neural plasticity and sensory integration occur in the developmental order, and brain functions integrate with the related systems hierarchically. 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 1972b, 1979).

Three main sensory systems play a role in the growth and development of the child - tactile, vestibular, and proprioceptive systems (Williamson and Anzalone 2001):

1. *Tactile System*; provides information about the environment by the sense of touch. The stimulus of the tactile system is received by the receptors in the skin which is the largest organ of the body. The tactile system has two components. The first is the protective system which informs when touching is harmful, and the other is the discriminative system which informs of the difference between harmful and beneficial touch.
2. *Proprioceptive System*; is a system which receives sensory stimulus from the muscles and joints. Push and pull activities related to muscles and joints provide maximum stimulus to this system. The proprioceptive system is also important for the development of fine and gross motor muscles. The insufficient proprioceptive system also negatively affects motor planning ability.
3. *Vestibular System*; Vestibular system receptors are within the inner ear and are related to hearing. The receptors in this system respond both to movement and gravity. The vestibular system is a system that affects balance, eye movements, posture, muscle tone and attention.

Assessment

In a child with an intellectual disability; motor, perceptual and cognitive skills should be considered comprehensive assessments. A multidisciplinary team consisting of a doctor, physiotherapist, occupational therapist, psychologist, language and speech pathologist, social worker and special educators will make the best assessment and intervention plan for the child. In all levels of function, motor development, oral function and nutrition, sensory integration, seeing, hearing and intelligence should be assessed (Swaiman 1989).

In the functional assessment, one or more measurement results are used in making some decisions about the functional performance of the child (Ottenbacher et al. 1999, Ottenbacher et al. 2000, Uyanik et al. 2003b).

These measurements can be divided into three groups which assess the measurements of motor functions, activities of daily living (ADL), and make developmental assessment. The majority of the tests examine both motor functions and daily-life activities (Taggart and Aguilar 2000).

Two commonly used pediatric functional assessment methods are The Functional Independence Measure for Children (WeeFIM®) and Pediatric Evaluation of Disability Inventory (PEDI). WeeFIM® comprises 13 motoric-based daily living skills and 5 cognitive items (Msall et al. 1994). PEDI is a comprehensive test consisting of 197 items used in the assessment of self-care, mobility and social functions of children between 6 to 90 months of age (Haley et al. 1992).

In Occupational Therapy, the focus is on the assessment of occupational performance. Occupational performance areas (self-care, productivity, and leisure), performance components (mental, physical, sociocultural, and spiritual), and environment (physical, social, cultural) should be assessed (Watson 1992).

The following are the occupational therapy tests that can be used specifically in the assessment of mental retardation:

- Loewenstein Occupational Therapy Cognitive Assessment-LOTCA (Itzkovich et al. 1993) for the assessment of cognitive problems
- Automatic Postural Reactions Tests (Bobath 1990) for the assessment of motor functions
- Gross Motor Function Measure-GMFM (Russell et al.1993) for the assessment of gross motor functions
- AAMR Adaptive Behavior Scale-School Second Edition (Lambert et al. 1993) for the assessment of adaptive behavior processes
- The Pediatric Clinical Tests of Sensory Interaction for Balance (P-CTSIB) (Richardson et al. 1992) for the assessment of balance deficits in children
- Southern California Postrotary Nystagmus Test (SCPNT) (Ayres 1975) for the assessment of vestibular functions
- Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) (Bruininks 1978) for the assessment of motor skills
- Southern California Sensory Integration Tests (SCSIT) (Ayres 1972b) for the measurement of sensory perceptual motor performance
- Sensory Integration and Praxis Tests (Ayres 1989) which consist especially the assessment of praxis and sensory integration

Researchers who have used the assessment tests stated above have determined the condition range of children with special needs (Kantner et al. 1976, Russell et al. 1998, Uyanik et al.1999, Uyanik et al. 2001, Uyanik et al. 2003b, Düger T et al. 1999, Tural et al. 2001, Bumin et al. 2002, Jobling 2006, Aki et al. 2007).

Interventions in Sensory Integration Dysfunctions

The fundamental principle in the intervention of sensory integration dysfunctions is enabling planned and controlled sensory stimuli with adaptive responses in order to increase the level of organization of the brain mechanism. The therapist's role in sensory integration programs is to arrange the stimuli coming from the environment so as to enable the individuals to demonstrate appropriate motor behavior, and develop self-care, play and school skills (Troyer 1961). Ayres stated that sensory integration is significantly related to the development of hearing and language skills besides motor coordination (Ayres 1979).

Sensory integration assessment, which is performed prior to sensory integration intervention, enables analyzing, synthesing, and interpreting the individual's sensory-perceptual motor behaviors. The assessment consists of the assessment of sensory motor process integration, the adaptation process of the individual, the effects of the maturation and behavior process and defining the developmental profile (Dengen 1988, Ayres 1989, Ayres 2005).

Acquiring skills requires the integration of information. In enabling the child to acquire skills, the therapist uses oral stimuli, supportive visual stimuli, the positioning of the child, passive movement and the suitable environment. The first stage in enabling the learning of the skills is to direct the child toward the desired goal (Gentile 1992).

There are four fundamental principles in the intervention of sensory integration dysfunctions:

1. The intervention process begins with assessment. The assessment of sensory-motor state and environmental adaptations are important in assessing the effect of the intervention, intervention methods and urgent therapeutic goals. The issues below should be considered in order to plan the intervention:

   1. The level of function of the child
   2. The developmental status of sensory integration process of the child
   3. What are the primary aims of the intervention and what intervention methods should be used with what purpose?
   4. How often should the child be treated and what home programs should be given?
2. The intervention program should follow the sequence of motor development seen in typically developing children. When the individual achieves highly controlled behaviors such as running, hopping, writing, and reading, an improvement in the assimilation and adaptation process of the visual, tactile, proprioceptive and vestibular stimuli occurs. Integrating intervention activities into the general play of the children in the program can be beneficial.
3. The intervention depends on the intersensory integration process. The organization of sensory stimulus which is internalized by the adaptation of the body, and the sensory integration process are the main steps of the intervention.
4. It should also be noted that home care for the child provided by parents and family and emotional and social development also play an important role in the intervention. The child's success depends on the therapist's communication and coordination with the patient's family and with other disciplines while planning the intervention program. Specialized programs depend on the age, gender, function loss, skills and interest of the child and the therapist's education (Gilfoyle and Grady 1971, Dengen 1988).

Activity training for sensory perceptual –motor dysfunction

The appropriate adaptation of the environment is very important in the intervention of sensory integration. The environment should be interesting to the child. The following activities are suggested in sensory integration intervention according to the child's proper sequence of development:

1. **Tactile, vestibular, proprioseptive input and feedback**

   Gross motor accommodation; gross postures and patterns of motion (rolling pivot prone, on elbows, all fours, standing, walking in unusual patterns and different surfaces, running, hopping, jumping on twister spots, catching, throwing)

   Motor planning (praxis): is the ability of the brain to conceive of, organize, and carry out a sequence of unfamiliar actions as necessary when learning new skills. Activities directed toward goal achievement help to develop motor planning skills. Net hammock and ball activities can help to improve gross motor accommodation and praxis.

2. **Tactile, vestibular, proprioseptive input and feedback**

   Righting and equilibrium reactions, and integrative patterns of different positions can maintain these stimulations. Play of boat in the ocean in the quadruped position can facilitate balance and equilibrium reactions. Therapists say "you are a boat in the ocean, and I am the hurricane you should try not to fall down" and therapist pushes the child very slowly for couple of times in order to disrupt the child's balance (Kramer 2007).

3. **Tactile, vestibular, proprioseptive and visual input and feedback**

   Apedal and quadrupedal activities; skooter board, bean bag, ball playing, rolling, crawling, relays, follow the leader, rhythm bands etc.

   Ocular control: activities which require the movement of hands and large muscle groups such as throwing and catching, and activities which require little muscle movement such as drawing pictures and drawing lines help to develop ocular control.

4. **Tactile, vestibular, proprioseptive and visual input and feedback**

   Activities for bipedal positions; running, jumping, skipping, hopping games, playground equipment(swings, barrels, slide, climbing bars), ball playing, musical games.

Bilateral motor coordination: When both sides of the body work together in coordination, purposeful hand movements appear and the child can cross the midline of his body.

Proprioceptive activities: climbing, pushing, pulling, carrying heavy objects, working against resistance and pressure

Visual–Spatial Perception: Children with dysfunctions of visual space perception have difficulty in writing and working with numbers. Learning and understanding direction concepts help to develop visual space perception. Activities directed toward vestibular and ocular controls which require knowing the position of objects in space help to develop visual-spatial skills. It is stated that there is a strong relation between visual perception and motor performance (Brien et al. 1988). Motor planning activities and visual space perception games have motor planning components, because motor planning and visual space perception interrelate. Motor activities such as walking, running, stair climbing can be structured to encourage a child to attend visually to spatial features (Kramer 2007). Serial activities (e.g nesting cups and graduated pegs) and many constructional tasks (puzzles, block designs, and graphic copying) can be given as examples to visual– spatial perception.

5. **Tactile, proprioceptive and visual input and feedback**

In the learning of fine motor skills, appropriate postural stability is important. Also good co-contraction of head, neck and arm muscles is required. Good ocular control, bilateral motor coordination and tactile sense affect hand functions. The child needs activities which consist of all these components in order to develop fine motor skills. For example; puzzles, finger plays, origami, peg boards (Ayres 1979, Lerner 1985, Scheerer 1997, Wilson 1988, Bumin and Kayihan 2001, Uyanik et al. 2003a).

The Role of the Vestibular System in Motor Development

The vestibular system is important in the achievement of normal motor development and coordination (Weeks 1979a, Cohen and Keshner 1989a, Cohen and Keshner 1989b, Shumway-Cook 1992). The vestibular dysfunction is observed in many developmental disorders as motor discoordination and learning disabilities (Magrun et al. 1981, Schaaf 1985, MacLean et al. 1986, Horak et al. 1988, Shumway-Cook 1992). The vestibular system is one of the first sensory systems that develop prenatally and is functional at birth due to the completion of its structure anatomically (Shumway-Cook 1992).

Normally, vestibuloocular inputs are significant in eye-head coordination which is important for stabilizing the look at one point, whereas vestibulospinal inputs are significant in maintaining postural stability with visual and somatosensory inputs (Nashner et al. 1982). The vestibulonuclear complex, the cerebellum and the reticular formation have reciprocal associations and affect motor behavior. The vestibular system is one of the wide sensory systems. Fibers pass into the vestibulonuclear complex from which they pass into the cerebellum and also into the 3. 4. 6. cranial nerves that enable extra ocular muscle movements and into all spinal levels that affect muscle tone (Ottenbacher and Petersen 1983, Kelly 1989).

The vestibular system is particularly important in the development of motor skills, the integration of postural reflexes, forming coordinated eye movements, and visual attention skills, and also in developing inquiring-behavior, and regulating the level of liveliness (Ottenbacher and Petersen 1983).

In contrast to children with isolated vestibular pathology, serious problems are observed in the motor sufficiency of children who demonstrate insufficiency in efficiently organizing visual somatosensorial inputs and normal vestibular inputs for postural control. Therapists who treat children with vestibular dysfunction stimulate the vestibular system with equipment such as swings, scooter boards, and hammocks (Shumway-Cook 1992). Ayres stated that, according to the sensory integration theory, the effect of vestibular stimulation in the central nervous system stems from the plasticity of the nervous system, and that the improvement observed in children in the period following the intervention is continuous because of undeveloped brain plasticity (Ayres 1972a, 1979).

The following can be beneficial as *the therapeutic effects of vestibular stimulation* (Weeks 1979b, Magrun et al. 1981, Pfaltz 1983, Sandler and McLain 1987, Arendt et al. 1991, Dave 1992, Uyanik et al. 2003a, Uyanik et al. 2003c):

1. Developing gross motor functions and reflex integration
2. Regulation functional balance
3. Increasing perception-motor skills
4. Developing hearing-language skills and intellectual functions
5. Increasing socio-emotional development
6. Decreasing self-injurious and/or stereotypical behavior
7. Helping the beginning of intervention by enabling individuals to be more receptive to the different forms of intervention

In assessments of determining the indication of the vestibular stimulation intervention, it is necessary that most of the following findings have positive outcomes: shortening of the post-rotary nystagmus duration, inefficiency in pivot prone (prone extension) position, hypotonicity in extensor muscles, weakness in equilibrium and support reactions, decrease in (co-contraction) joint stability, feeling of gravitational insecurity, and intolerance to movement (Fisher and Bundy 1989).

Vestibular stimulation intervention methods

In the application of vestibular stimulation, the structure and position of the vestibular stimulus is significant in the efficiency of stimulation. Whether the vestibular stimulation has excitatory or inhibitory effects is determined by the form of the stimulation. Slow, rhythmic, and passive movement has inhibitory effect; rapid movement has excitatory effect. Rotational movement and linear acceleration-deceleration stimulate different receptors. Different types of sensory stimuli form by rolling, and swing back and forth. In addition, positioning upside down, lying prone and supine or side-sitting activate different parts of the canals and otoliths at different degrees. The horizontal position and especially the prone position activate otoliths more efficiently than the upright position. The horizontal position is also the best position for semicircular canal stimulation. Ayres pointed out that different head positions and movements are necessary for the stimulation of vestibular receptors, but particularly the horizontal position is more important (Ayres 1979, Kelly 1989).

Types of vestibular stimulation:

1. To normalization of extensor muscle tone by increasing otolith organ input, linear activities are given in accordance with the order of motor development. These are:
    a. bouncing-jumping activities (whilst sitting, kneeling, or standing)
    b. linear swinging activities (using platform and T-swing, glider, hammock and barrel swinging in kneeling, standing, sitting, creeping and, prone and supine positions)
    c. other linear activities (jumping or falling onto pillows or mattress in sitting, prone and supine positions)
2. To development of equilibrium reactions by increasing semicircular canal responses, the center of gravity is changed to create disorganization for a short time and thus phasic head movements are made to appear. For this,
    a. by moving the support surface, the center of gravity is changed as active or passive.
    b. by pushing-pulling activities, displacement of the center of gravity is created. These are activities which enable active equilibrium on steep surfaces such as stairs, ramps and unfamiliar surfaces by using equipments such as balance boards, therapy balls and barrel.
3. To lessen the fear of movement or positional change by increasing the weak passing of otolith input, linear vestibular stimulation is applied in tolerable speeds and durations and in unthreatening positions (Fisher and Bundy 1989).

There are a number of precautions to consider the vestibular stimulation:

1. As a result of over stimulation, sensory overload occurs and this results in organization dysfunctions in the central nervous system. Therefore, over stimulating should be avoided, and before, during, and after vestibular stimulation, the child should be checked for evidence of over stimulation or

under stimulation and allowed to determine his own speed.
2. The over inhibition of the brainstem is the greatest potential harm resulting in seizures, cyanosis, and depression in vital functions.
3. In children with hypertonicity, a counter effect in the form of more tone increase may occur.

Sensory stimulation response is different in each child, and the child should be checked carefully at this time (MacLean et al. 1986, Fisher and Bundy 1989).

Neurodevelopmental Therapy Approach

The Neurodevelopmental Therapy Approach (NDT) which is one of the most common intervention methods utilized in the intervention of children with developmental dysfunction was first used in the therapy of children with cerebral palsy. Later, it was used in the intervention of many developmental disabilities. The NDT approach focuses on the normalization of hyper or hypotonic muscles, the specific handling intervention of equilibrium reactions and the child's movement and its facilitation. NDT is a popular therapy method within the intervention approaches of infants and children with neuromotor dysfunction (Bobath 1980, Harris 1981).

NDT has included three basic components related to neuromotor control:

1. Postural tonus
2. Reflexes and reactions
3. Movement patterns

One of the primary purposes of NDT is the facilitation of normal muscle tone in order to maintain normal postural and movement patterns. For this purpose, researchers have focused on a complex facilitation-inhibition process for many years. The Bobaths recognized that inhibition is a major factor in the control of movement and posture. It is considered to be important in the development of selective and graded movement for function. Many studies on the effects of NDT were conducted by Bobaths and other researchers, and the outcomes were satisfactory (Bobath and Bobath 1967, Bobath 1980, Bobath 1990, DeGangi et al. 1983, Ottenbacher et al.1986, Lilly and Powell 1990, Mayston 1992).

In the Bobath method, the child's functional skills are observed, and analyzed. The intervention is based on this detailed analysis, and it is customized. With functional activity education, the effects of the intervention are increased. In this approach, normal postural reactions, or problems in the relation between the central postural control mechanism and coordination need to be defined first. For automatic and voluntary activities, normal postural tonus, normal reciprocal interaction of the muscles and automatic movement patterns are priorities. All upper motor neuron lesions can be described as a disturbance to this mechanism, resulting in abnormal postural tone (spasticity, hypotonia, fluctuating tone), disordered reciprocal interaction of muscles (overfixation, lack of grading), and a disturbed automatic background of activity on which skills can be performed (Mayston 1992).

The Bobath method was used with more dynamic and functional approaches in later years. Automatic righting, equilibrium and protective reactions which were thought to be the basis of functional and voluntary movements began to focus on the facilitation. In order to enable the child to control equilibrium reactions and movements by himself, technical approaches that were applied manually were utilized less. In such an approach, because the child's reactions are corrected by the therapist's techniques, more interaction takes place between the therapist and child with a disability (Mayo 1991).

Combined Interventions

In studies conducted in the child with an intellectual disability, researchers facilitated normal mental and motor development by utilizing different stimulation techniques together. In children with developmental problems, approaches such as sensory integration intervention, perceptual-motor intervention, neurodevelopmental therapy, vestibular stimulation, play therapy, language-cognitive approaches are more effective when used individually or consecutively as may be required (Bobath and Bobath 1967, Ayres 1972a, Ayres 1979, Bobath 1980, Bumin and Kayihan 2001, Uyanik et al. 2003a, Jobling 2006).

The purpose of the NDT approach used together with play therapy is to develop individual cognitive and perceptive skills, to enable appropriate activity experiences that provide stimulus to normal movement patterns and to motivate the child by supporting normal developmental needs within the program. For this purpose, by performing activity analysis first, the therapist determines the important sections of the activity according to the child's needs and NDT targets. In this analysis, the child's motor, cognitive, perceptual and psychosocial needs and activity components are assessed. In addition, the specific NDT instrument is determined according to the child's needs. Subsequently, by giving play activities suitable for NDT techniques, the therapist enables the child's active participation in daily life activities (Anderson et al. 1987).

In enabling the child to acquire skills, the interaction of human and non-human environmental factors is significant. Therefore, the intervention should be directed not only by taking the child into the program but also by environmental adaptations that increase the child's functioning and by activities such as play activities that are multipurposeful. Thus, the child actively participates in the intervention process, 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. 1982a, 1982b). From this concept, Child-Centered intervention and Structural-Developmental intervention terms were defined to be used in the intervention of infants and young children with attention and emotional problems. In Child-Centered intervention, the child starts the play activities, and the therapist is the observer and facilitator. As in approaches applied in Snoezelen or multimodal sensory rooms, the environment is organized by arranging the available toys and materials, and a safe environment is created in which sensory-motor development can be increased without imposing prohibitions, or creating a feeling of failure (Uyanik et al. 2009). In the Structural-Developmental intervention approach, the child is taught how to gain developmental skills, and how to develop motor functions needed for sensory integration and skill performance. While this intervention is being applied, NDT or perceptualmotor training techniques can be used together to facilitate the child's performance (DeGangi et al. 1993).

General principles of combined programs applied on child with an intellectual disability as follows:

1. By taking the children's intelligence into consideration, activities that are easy to learn, and comprised of the easiest possible movement components are chosen.
2. The order of normal development is followed in the program. Following the assessment of reflex development, the appropriate activities are chosen after determining the level of weakness of integration between the child's response at one level below and top level adaptation behavior. The activities are adapted to supine-prone position, quadruped, sitting, and standing positions within the order of development.
3. By having each child work alone in the same room, confuse effects which may be caused by other people or the room arrangement are avoided.
4. By utilizing each equipment appropriately during programs, the amount of stimulation is adjusted to the tolerance level of the child. By equipping the therapy room with equipments that provide different sensory stimulations, play surroundings alternatives are created within the environment, thus enabling attentiveness and motivation.
5. In the improvement of sensory-perception-motor responses, the development of proprioceptive feedback is beneficial. Motor responses of the child are aimed to be increased by using methods such as positioning and movement activities, and applying resistance, and by utilizing touch, and equilibrium stimuli. By increasing visual stimuli besides touch and proprioceptive equilibrium stimuli, postural and motor adaptation is aimed to be achieved.
6. The program is carried out step-by-step, from easy to difficult and only progressing once the skill in the previous step has been accomplished (Gilfoyle and Graddy 1971).

DeGangi et al. 1993 stated that the following are the issues to be considered while applying the sensory-motor approach in a combined intervention of child-centered activity and structural-developmental intervention respectively:

- Behaviors and searching for the sensory stimulation that is needed for the self-organization of attention and motor movements
- Forming the idea of motor movement in the general concept of play, and developing the plan

- Organizing motor movement patterns according to activity requirements
- Increasing tactile-proprioceptive and vestibular sensory inputs which are formed in daily activities
- Practicing postural control and balance
- Putting bilateral integration components in order and teaching of their patterns
- Teaching of motor planning components with the external direction of the therapist
- Enabling the acceptance of sensory stimulation under the direction of the therapist and enabling this to be used
- Observing and controlling behavioral responses to sensory inputs

The following are the issues to be considered while applying the neurodevelopmental therapy approach in a combined intervention of child-centered activity and structural-developmental intervention respectively:

1. Creating motivation for movement and starting the movement
2. Self-generation of the planned activities
3. Detailed planning of body movements in space
4. Practicing motor movements in play schemas
5. Putting motor movements in order, timing, and planning
6. Satisfaction in motor activities
7. Developing posture and movement components
8. Practicing real-skill performance
9. Eye-hand coordination
10. Equilibrium, strength, and postural adaptation, and stability

The following are the issues to be considered while applying the functional approach (Activities of Daily Living-ADL) in a combined intervention of child-centered activity and structural-developmental intervention respectively:

1. Developing a feeling of interest in performing daily activities and motivation
2. Developing the effort of self-expression by using various activities such as drawing
3. Experiencing learned functions by using daily life devices
4. Developing visual-spatial skills within the environmental setting
5. Developing creative self-expression through play, artistic activity, movement and other activities
6. Developing more complex play levels
7. Practicing self-care skills
8. Developing perceptual and visual-motor functions which are necessary for learning
9. Transferring skills learned in therapy to the school and home environment (DeGangi et al. 1993).

Family Education

To help develop the potential of the child, education and rehabilitation programs should be initiated in the neonatal period. The aim is to establish a close relationship between the infant and the family and start developing independence in occupational performance areas in developmental milestones. It is important that the family is aware of the help they can get from the professionals and the areas of learning in which the infant needs stimulation. Ayres stated that there are five important things that parents can do:

1. recognize the problem so that they will know what their child needs
2. help their child to feel good about himself
3. control his environment
4. help him learn how to play, and
5. seek professional help (Ayres 2005)

Sensory integration, vestibular stimulation, neurodevelopmental therapy approaches etc. (combined sensory-motor and language-cognitive approaches) together with educational, behavioral and pharmacological interventions on a lifespan focus for the child may be beneficial. All children with Down syndrome do not progress at the same rate and progress is slow. Other factors such as health needs often limit the time available in the typical developmental period but with ongoing assistance motor milestone can be attained and supported (Uyanik et al. 2003a, Jobling & Virji-Babul, 2004).

Family education within early intervention programs for infants should give importance to the prone position and the variety of movement, and should consist of occupational therapy / physiotherapy programs toward the development of postural reactions, proprioceptive and vestibular stimulation, the perception of the sense of touch and body awareness, ocular control and the development of visual-motor coordination. As the child grows up, educating the family on sociocultural and spiritual components, besides mental and physical components of occupational performance, will increase the success of social integration of the child with an intellectual disability.

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