CASE STUDIES

Enhancing Eye-Hand Coordination with Therapy Intervention to Improve Visual-Spatial Abilities using 'The Re-training Approach' in Children with Down Syndrome: Three Case Studies

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ABSTRACT

Eye-hand coordination and visual-spatial abilities are an integral part of a child's development, since both skills are necessary for functional independence as well as for academic progress.

Purpose: *This study is aimed at understanding the relationship between visual-spatial abilities and eye-hand coordination based on the 'Re-training Approach'. An underlying assumption of this approach is that skills learned for one task can be generalised to other areas.*

Method: *Three children with Down syndrome were initially tested for eye-hand coordination, and the tests were repeated periodically throughout the intervention programme which comprised visual-spatial activities.*

Results: *The authors observed that there was a steady improvement in the eye-hand coordination as well as the visual-spatial abilities of children involved in the intensive therapy programme. This improvement manifested in the reduction of time taken to perform the coordination tests and in the errors made while performing the tests.*

Key words: *Eye-hand coordination, Re-training, Down Syndrome.*

INTRODUCTION

Down syndrome occurs with equal frequency in people of different nationalities, social backgrounds and economic classes, averaging 1 in about every 600 births.

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Wide variations occur in the developmental sequence for children with Down syndrome. Though they go through the same developmental stages as other children, it is often at a delayed pace. One common characteristic that hampers their development is low muscle tone (hypotonia), characterised by floppy or overly relaxed muscles.

Motor skills development is the most crucial and overtly evident aspect of a child's development in the initial years of life. Motor development is an ongoing process influenced by a number of factors that include the maturation of the nervous system, an individual's genetic make-up, as well as the dynamic interaction between the individual and the environment. Motor learning involves a significant amount of practice and feedback, with a high level of information processing to control, error detection and correction. Motor learning can be facilitated through the use of effective training strategies (O'Sullivan & Schmitz, 2007).

Hand-writing and drawing are complex perceptual motor tasks that require arm and shoulder strength and postural stability to produce coordinated and controlled movements. Hence, many children take considerable time to master all the perceptual motor aspects of these tasks.

Spatial relations or visual-spatial processing ability is the capacity to localise objects in relation to each other and understand the location of objects with respect to oneself (Zoltan, 2007). Through the perception of spatial relations, an individual can judge distances, distinguish forms and separate objects from a surrounding background. Spatial relations are important for orienting in the environment - recognising objects, scenes, language, and for manipulation of objects by hand.

The theoretical basis for the acquisition of spatial relations has been explored. Some theorists focus on the importance of spatial attention (Logan, 1994). They envision the apprehension of spatial relations to involve the coordination of perceptual and conceptual representations of space.

Research suggests that both the right and the left brain hemispheres can compute both types of spatial relations but not equally effectively (Sergent, 1991). Theorists conceptualise a clear distinction between categorical spatial relations, such as above-below, left-right, on-off, and coordinate spatial relations, which specify locations in a way that can be used to guide precise movements.

Spatial relations deficits can result in difficulties with tasks such as aligning buttons of a shirt, discerning which side of the shirt is front and which side is back, or perceiving whether the arm went through the armhole or the neck hole (Zoltan, 2007). Spatial relations deficits lead to difficulty in perceiving the relationship between objects in space, or the relationship between the self and two or more objects. Spatial relations disorders include impairments of figure-ground discrimination, form discrimination, spatial relations, position in space and topographical disorientation. Along with this, constructional apraxia and dressing apraxia are also viewed as spatial relations difficulties (O'Sullivan & Schmitz, 2007).

Cognitive and perceptual deficits are two of the most puzzling and disabling difficulties that a person can experience. Thinking, remembering, reasoning and making sense of the world around us is fundamental to carrying out daily living activities. The perceptual-motor process is a chain of events through which the individual selects, integrates and interprets stimuli from the body and the surrounding environment. Basically perception includes both cognition and visual perception as sub components (O'Sullivan & Schmitz, 2007).

Coordination is the ability to execute smooth, accurate controlled motor responses. Visual motor coordination refers to the ability to integrate both visual and motor abilities within the environmental context to accomplish a goal, e.g. tracing a zigzag line, writing a letter or riding a bicycle. A sub-category of visual motor coordination with important implications for activities of daily living is eye-hand coordination which is required for using cutlery, personal hygiene or reaching for a visual target (O'Sullivan & Schmitz, 2007).

Coordination can be affected by delayed development as well as low muscle tone. Constructional apraxia is an impairment when producing designs in 2 or 3 dimensions (copying, drawing or constructing), whether upon command or spontaneously. The performance of constructional tasks, in fact, pre-supposes normal visual acuity - the ability to perceive several elements of the model as well as their spatial relationship, and sufficient motor ability.

THEORETICAL FRAMEWORK

The Re-training Approach: This approach was described by Averbuch and Katz (1992), and focuses on the remediation of underlying skills. It is sometimes referred to as the 'transfer-of-training' approach. It is based on the assumption that a disruption in one region of the brain can have a negative impact on brain functioning as a whole. An underlying assumption of this approach is that skills learned for one task can generalise to others. The premise underlying transfer-of–training is that practice in one task with particular cognitive or perceptual requirements will enhance performance in other tasks with similar perceptual demands (Neistadt, 1994; 1995). Young et al (1983) demonstrated that training persons with left hemiplegia in block design, in addition to visual scanning and visual cancellation tasks, resulted in improvements in reading and writing, although no specific training in these areas was offered (Young et al, 1983).

Neistadt (1995) suggests that a person's capacity to learn must be evaluated, and that learning capacity is the key to the person's ability to generalise the material learned in one situation to others. If transfer of training does occur, then strategies to enhance this can be incorporated into other components of the treatment programme, such as those aimed at maintaining sitting balance, weight-bearing exercises or the functional use of the affected extremities (O'Sullivan & Schmitz, 2007).

As there is insufficient evidence that transfer-of-training has been studied in children with Down syndrome, this study has focused on the subject. The objective of this study is to relate the improvement in coordination to improvement in visual- spatial abilities in a child with Down syndrome, by using the transfer-of-training theoretical framework.

METHOD

The study was initiated after observing the visual-spatial deficits presented by two boys and one girl with Down syndrome.

The inclusion criteria were:

1. The child should be diagnosed with Down syndrome.
2. The child should be between 9-11years of age.
3. Visual-spatial deficits which hinder the eye-hand coordination should be present. This would have an impact on the child's functional performance in Activities of Daily Living [ADL] skills and academics.
4. Parental consent was mandatory.

Among the four children identified, one child was not included as parental consent was not obtained. The three children who participated were from Asian families belonging to the mid-level income group.

The individual children's profiles are as follows:

- Child A is a 9-year-old boy with Down syndrome. He was found to have deficits in visual perceptual skills - mainly depth perception, visual discrimination, visual sequential memory and visual spatial relationship, thus hindering his performance in self-help skills such as eating with cutlery, and in the quality of his handwriting, colouring and complex matching skills.
- Child B is a 7-year-old boy with Down syndrome. He had deficits in visual perceptual skills - mainly depth perception, visual discrimination, visual form constancy, visual memory and visual spatial relationship, thus hindering his performance in self-help skills like eating with cutlery, performing grooming and dressing activities and in the quality of his writing, colouring and matching skills.
- Child C is a 9-year-old girl with Down syndrome, with deficits and difficulties identical to Child B.

Prior to the commencement of training, the selected students were evaluated for their eye-hand coordination skills based on tasks listed in the Coordination Test.

Figure 2: Coordination Tests

Coordination Tests	
Test	**Description**
Drawing a circle	While sitting, standing, or lying down, the patient alternately draws an imaginary circle in the air, or on a table or floor, with either upper or lower extremity. Instead of a circle, a figure-eight pattern may be used.
Finger to finger	With both shoulders abducted to 90° and the elbows extended, the patient is asked to bring both hands toward the midline and approximate the index fingers from opposing hands.
Finger to therapist's finger	The patient and therapist sit opposite each other. The therapist holds his or her index finger in front of the patient, and the patient is asked to touch the tip of the index finger to the therapist's index finger. The position of the therapist's finger may be altered during testing to assess ability to change distance, direction, and force of movement.
Pronation/ supination	With elbows flexed to 90° and held close to body, the patient alternately turns his or her palms up and down.
Tapping	Hand: With the elbow flexed and the forearm pronated, the patient is asked to "tap" his or her hand on the knee.

Each child underwent an intensive programme implemented by the Occupational Therapists, before the results were drawn. Every session lasted for 30 minutes, 5 days a week, for 4 weeks. This individualised training was carried out in a distraction-free environment, at the intervention rooms of the Department of Occupational Therapy at the Al Noor Training Centre for Children with Special Needs.

The training process had four components: Matching Shapes; Constructing Block Designs; Copying Geometrical Shapes and Copying Pictures. Each of the four components was administered at graded levels with increasing complexity of the task. A child would move to the next level of performance only after he/she had achieved independence in the previous level. The details of the four training strategies are listed below:

Matching Shapes

The children had to match various shapes on a geometrical design board. The complexity of the task was increased by changing the orientation of the shapes and adding more number of shapes. When the child was able to perform the activity of posting 2-dimensional shapes independently, the therapists progressed to the sequencing task of stringing beads of two colours. Verbal prompts and assistance which were provided during the training phase were gradually faded out, to ensure independence in performing the tasks.

Constructing Block Designs

The children had to replicate a block design constructed by the therapist. The complexity was graded according to the number of blocks used to create the designs as listed below.

Level 1: 3-block design

Level 2: 4-block design

Level 3: 5-block design

Level 4: 6-block design

At each level the therapist varied the orientation of the block design to ensure the increasing complexity and generalisation of the skill. Physical assistance and verbal prompts were provided to the children during training, and gradually phased out to allow them to do the tasks independently.

Copying Geometrical Figures

During each session the children were asked to trace along dotted lines and then copy geometrical figures. The levels were determined based on the number of figures and increasing complexity of the shapes.

Level 1: Tracing and then copying the rectangular, circular and triangular shapes.

Level 2: Tracing and then copying the rectangular, circular, triangular and star shapes.

Copying Pictures

The children were trained to copy 2-dimensional pictures. The activity worksheets were sent home with them, so that training could be continuous during this period.

In all activities the children were initially provided with hand-over-hand assistance. As they made progress the assistance was gradually reduced and only verbal prompts were given. Later prompts were also withdrawn to enable independence in performing the tasks. Also, the complexity levels of all tasks were progressively raised by increasing the number of pictures, with each additional picture being more complex in its presentation than the earlier one.

At the end of every 5 days of training, the children were evaluated on their eye-hand coordination skills. The tasks performed in the coordination tests which were used for the initial assessment, formed the basis for the subsequent evaluations. The components associated with developing eye- hand coordination were listed and performances were judged based on the time taken for task completion and the number of errors made. The initial assessment and the periodic re-evaluation were conducted by one therapist.

RESULTS

All 3 children were observed to be independent in posting 6 shapes in a 3-dimensional activity at the beginning of the training programme. Since this was the ceiling level identified to facilitate progression, the training programme began with the task of placing 2-dimensional geometrical shapes on a given picture. When the children were able to post 2-dimensional shapes independently, this activity was substituted with sequencing tasks. This involved sequencing beads or small blocks using 2 colours alternately.

Child A and child B started the copying of block designs with 4 blocks, and child C started with 3 blocks. All 3 children began the replication of designs and copying drawings with 3 samples. Child A discontinued the programme as he was unwell, but the 3-week therapy record shows steady progress in his visual-spatial abilities.

The initial observation therefore suggests that the children were better able to perform constructive tasks which were 3-dimensional, as compared to paper-pencil tasks which were 2-dimensional. A steady improvement in the visual-spatial skills was seen in all 3 children over a period of 1 month of intensive intervention.

Fig 3[a] illustrates that child A took less time to perform the coordination tests during the 3rd evaluation as compared to the initial assessment. This indicates an improvement in the child's eye-hand coordination.

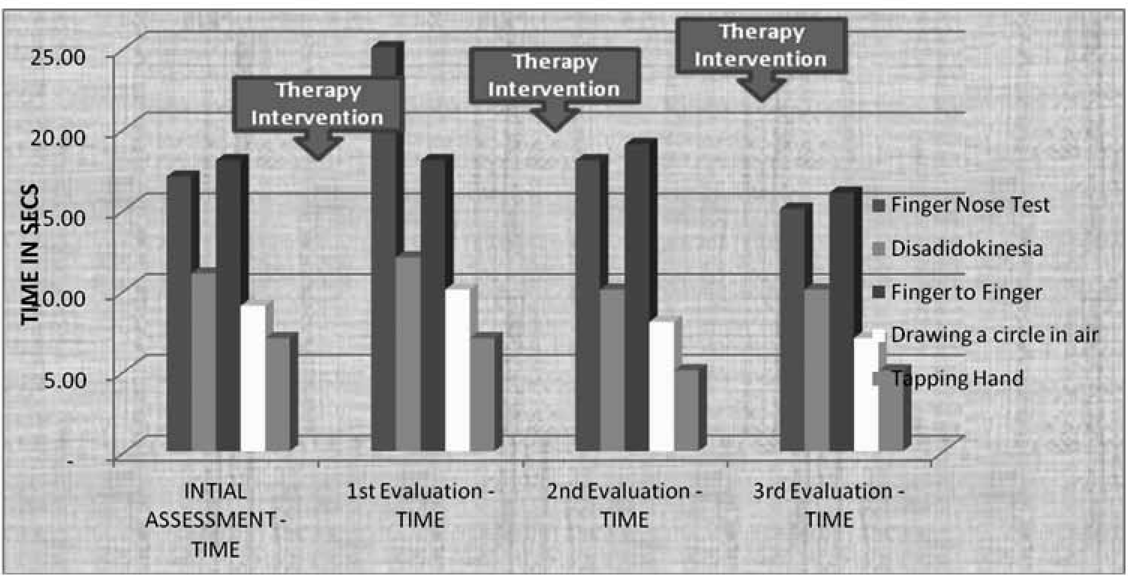


Figure 3 [a] CHILD A: Coordination Tests Results

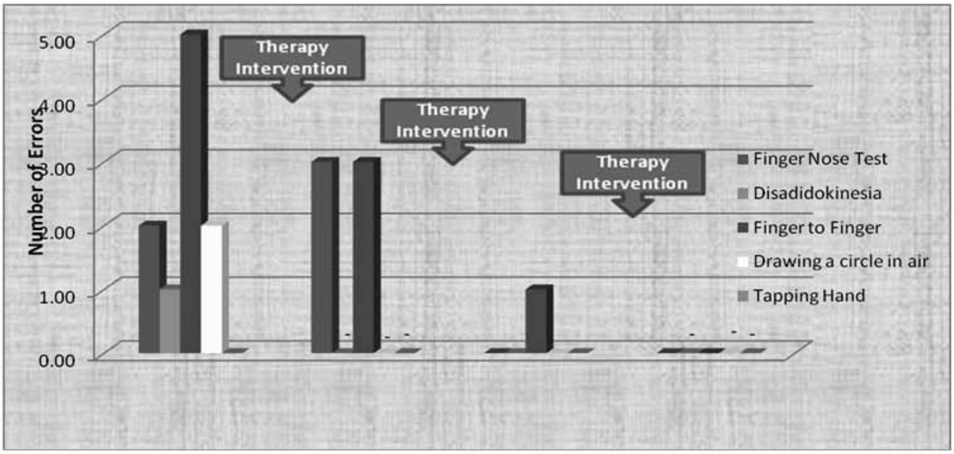


Figure 3[b] CHILD A: Reduction in errors during performance in coordination tests

Along with the reduction in the time taken to perform the coordination tests, child B was also able to perform the tests more accurately during the 4th assessment as compared to the initial assessment. Except for the 'drawing a circle in air' test, child B was able to perform the other coordination tests without making any errors (Fig 4 [b]).

Child C was able to perform the coordination tests with a better timing in the 4th evaluation as compared to the initial assessment, especially the 'finger nose' test which assesses eye-hand coordination.

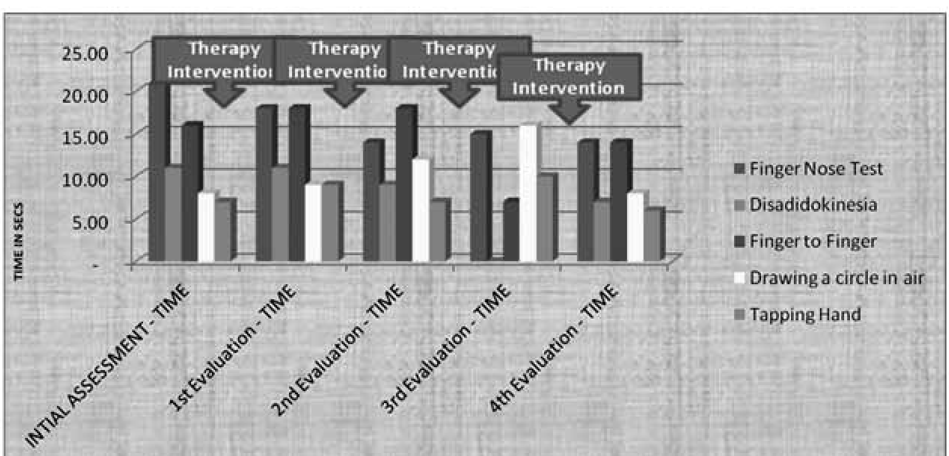


Figure 5 [a] CHILD C: Coordination Tests Results

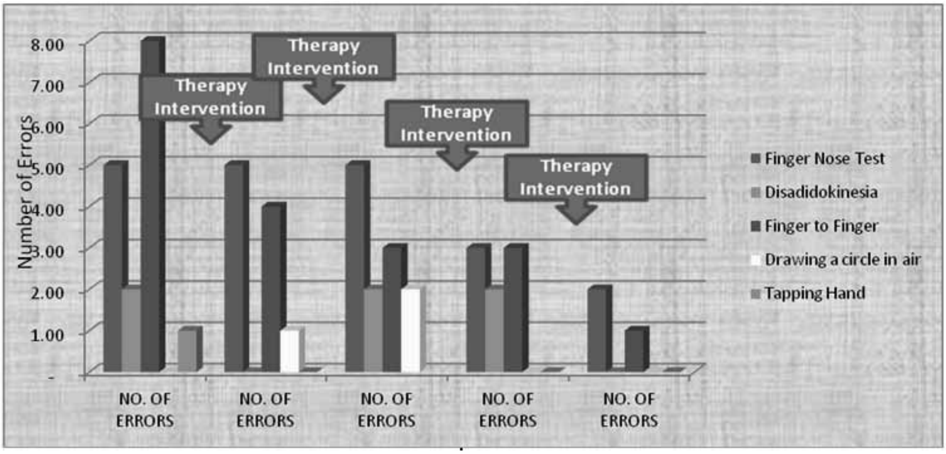


Figure 5[b] CHILD C: Reduction in errors during performance in coordination tests

By the 4th assessment, the number of errors committed by child C during the performance of the coordination tests had reduced steadily. Child C was able to perform the coordination tests of disadidokinesia, 'drawing a circle in air' and 'tapping hand' without any errors. Errors during the performance of eye-hand coordination tests ('finger nose' test and 'finger to finger' test) had also reduced consistently since the initial assessment.

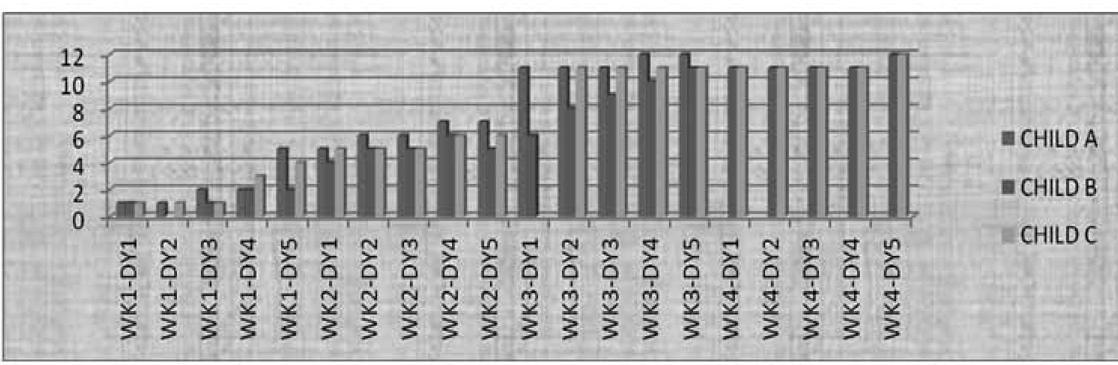
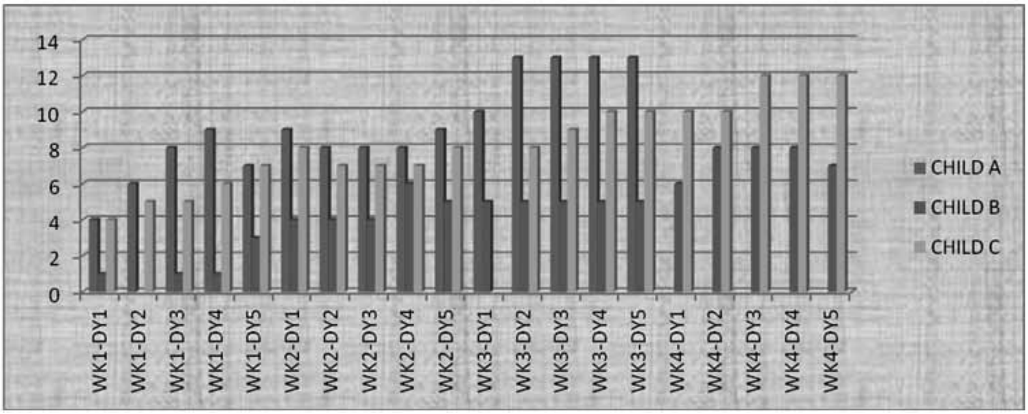


Figure 6: Performance of the three children over four weeks on POSTING SHAPES

All three children showed a steady improvement in their ability to post shapes into appropriate slots. This is an activity given to improve the figure-ground perception of the children (Fig 6).

Figure 7: Performance of the three children over four weeks on COPYING BLOCK DESIGN



Each child showed an improvement in the ability to copy designs. Figure 7 also indicates that the level of complexity achieved by each child was directly related to his/her initial level of ability in doing this task. For example, when the training started, Child A was performing at a higher level of complexity as compared to child B. Thereafter it was observed that child A was able to perform this task at a much higher level of complexity after three weeks of training, as compared to the level achieved by child B at the end of four weeks of training.

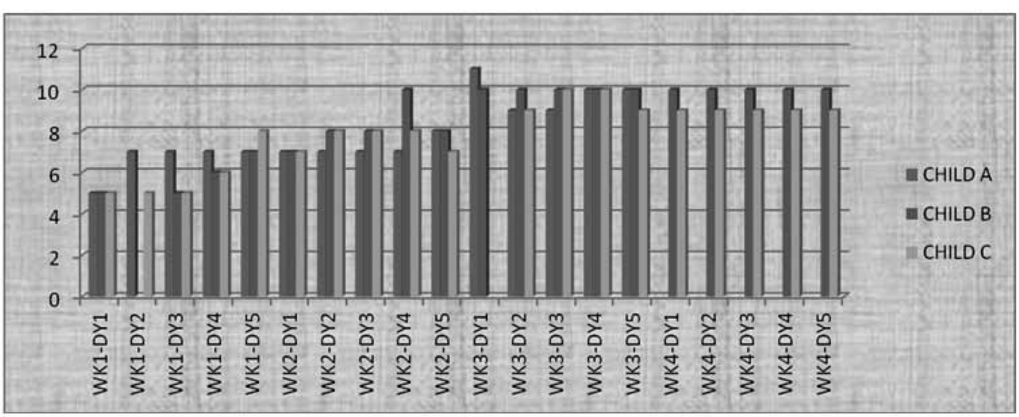


Figure 8: Performance of the three children over four weeks on REPLICATE 2-D DESIGN

Over the training period of 4 weeks, all three children improved in the performance of tasks of 2-dimensional design replication (Fig 8) as well as design copying (Fig 9).

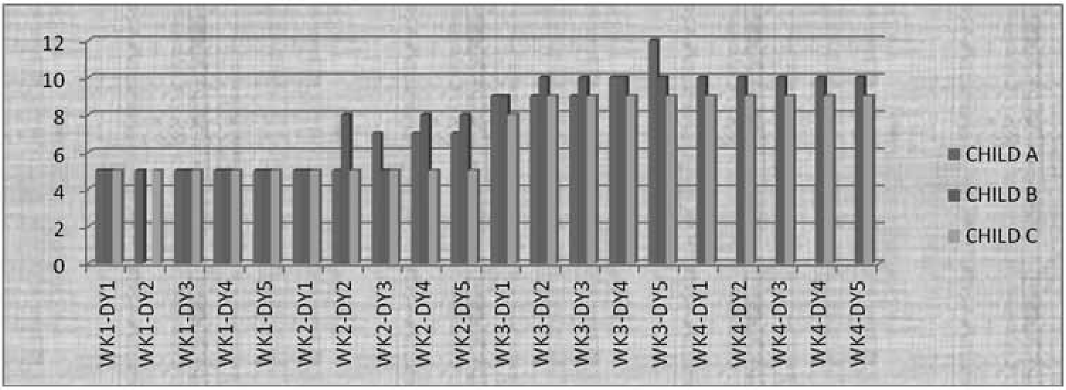


Figure 9: Performance of the three children over four weeks on COPY DESIGNS

Child B performed the paper-pencil tasks, namely, 2-dimensional design replication and design copying, better than child C, as shown in Figs 8 and 9.

DISCUSSION

During the course of the training there was limited follow-up and continuation of the activities at home. Minimal parental participation in this study has meant that the changes observed in the three children can be attributed to the training and intervention that was conducted in the therapy setting at the Centre.

Visual-spatial difficulties and disturbances in eye-hand coordination are some of the factors that can hamper a child's ability to read and write. This in turn will slow down academic progress. It has been observed that intensive therapy intervention and daily practice of visual-spatial skills have resulted in noticeable improvement in the children's abilities. Their academic abilities will also be enhanced. The transfer-of-training principle can be applied by using a variety of tasks to improve academic progress. Hence, therapy for improving visual-spatial abilities should be incorporated in the early intervention programme for individuals with Down syndrome. The transfer-of-training approach focuses on the remediation of underlying skills. An assumption of this approach is that skills learned for one task can be generalised to other areas. In this instance, the study sample comprised only 3 subjects. More research is needed to explore the efficacy of similar tasks in children with Down Syndrome and other disabilities. A longitudinal study should be done to explore the impact of the gains achieved in this form of training, and the transfer of those gains to academic skills and activities of daily living.

CONCLUSION

It may be concluded that a graded visual-spatial therapy programme will help to improve eye- hand coordination, an essential component of writing skills and other abilities, which will enhance the child's academic performance. This study is based on a general visual-spatial therapy programme during which 20 sessions were conducted over a period of 30 days. An individualised therapy programme administered over a longer duration must be studied to note the long-term effects.

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