Visual-Based Training Program for Motor Functions in Cerebral Palsied Children with Cortical Visual Impairment

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Abstract

Background/Aim: Cortical visual impairment (CVI) is a temporary or permanent visual dysfunction resulting from damage to the visual systems in the brain that deal with processing and integrating visual information. The aim of current study was to investigate the effect of visual-based training program on motor functions in cerebral palsied (CP) children with CVI.

Methods: Twenty six spastic CP children with CVI from both sex, ranged in age from 2 to 4 years, participated in this study. They were randomly assigned to two groups of equal number; control (I) and study (II) groups. Children in group I received the conventional physical and occupational therapy program inside the normally lighted room. Children in group II received the same program given to group I using visual stimulation modalities inside the sensory room. Treatment duration for both groups was 2½ hours, 3 days per week for a successive three months. Gross and fine motor functions were evaluated before and after treatment using Gross Motor Function Measure Scale (GMFM) and Peabody Developmental Motor Scale (PDMS) respectively.

Findings: This study showed a statistically significant improvement of gross motor skills in both groups (P=0.001), however, a significant difference was seen between both groups, but in favour to group II (P=0.000). Regarding fine motor skills, no significant improvement was seen in group I (P=0.15) however, significant improvement was obtained in group II (0.001) after treatment. Conclusion: Training of gross and fine motor skills using visual stimulation modalities inside sensory room is effective for CP children with CVI to improve their gross and fine motor functions.

Key words: Cerebral Palsy, Cortical Visual Impairment, Visual Stimulation, Occupational Therapy
Introduction

Cerebral palsy (CP) is the major developmental disability affecting function in children. It is characterized by the inability to normally control the motor functions, it can possibly affect the all areas of child’s development by influencing his/her ability to explore, speak, learn, and become independent. The motor disorders of CP are frequently but not always accompanied by disturbances of sensation, cognition, communication, perception and/or behaviour [1]. A child with CP may or may not have excellent visual acuities. He or she may oblige glasses to correct short/long sightedness or astigmatism. However, all children with CP will experience problems in visual processing - the ability to interpret what has been seen rather than just eyesight. There is a close relationship between visual skills and movement skills - one drives the other [2]. More than 40 – 75 % of children with CP have some types of visual problem or impairment [3]. They include strabismus, nystagmus, hemianopia and cortical blindness [4].

Cortical visual impairment (CVI) or blindness is a brain condition, not an eye condition and results from injury or damage to the visual systems of the brain (bilateral damage to the occipital cortex) [5]. It represents difficulty in processing and interpreting visual information in the visual cortex [6] and it is characterized clinically by bilateral loss of vision, with typical papillary response and an eye examination that demonstrates no different variations from the norm. The eye structure in CVI is usually normal. The eye receives a normal picture of the object and sends the message to the brain. The message is not appropriately processed or integrated due to abnormal brain function [7]. There are numerous etiologies of CVI, but most common is hypoxic ischemic injury [8] leading to periventricular leukomalacia. Other common etiologies related to CVI include: traumatic injury; shunt failure, meningitis [9] hydrocephalus, hypoglycemia, seizures, malaria, and neurodegenerative disorders [5].

Children with CVI demonstrate a developmental delay in head raising functions, rolling over, raising up on upper limbs, pushing back or forward and eventually sitting, crawling, creeping, cruising and walking are all accepted to be driven initially by visual stimulation triggered by something in the environment, coupled with the drive to obtain objects, explore and manipulate them and thus learn about them. Consequently almost all behavior is visually driven throughout life including all movements, reading, and writing, math, discovering and creating [10].

In addition, those children can have problem with visual concentration, depth perception and eye-hand coordination with getting around, recognizing objects, focusing for near objects, fast eye movement and visual field loss [11].

Children who present with multiple disabilities and visual impairment require a team approach for the planning of intervention and educational programs intended to address specific needs [12]. Effective interventions for children having CVI incorporate neural based stimulation methods and normal developmental sequences. Capitalization and natural inclinations such as our inherent susceptibility to notice faces, movement, high contrast and bright colors are highly recommended. This helps in maximizing visual attention and residual vision [13]. In children with CVI, visual stimulation programs are assigned according to the subject's initial level of visual function, with specific stimuli and intensity, frequency and duration assigned. Today, there is a variety of methods accessible to help the process of learning for those who have CVI with or without multiple disabilities. One of these methods is the multi-sensory environment or room [14].

Multi-Sensory Environments (MSEs) or rooms were pioneered in the late 1980’s for adults with significant and various learning difficulties and a number of MSEs were additionally settled for children in educational settings, particularly schools. The MSEs give a chance for passive leisure, generic sensory stimulation and teaching of specific skills (such as communication) for children with sensory needs in educational settings [15]. Generally, MSEs were made exclusively to give opportunities for leisure within residential settings, however over the previous years, have progressively been utilized as a part of educational settings to deliver educational and therapeutic interventions [16-17]. These differing functions of MSEs have been debated in the literature, however Stephenson [18] reported that a middle ground is developing where the utilization of the multisensory room is connected to the apparent individual needs of the student, and this may be for leisure (active or passive), therapy or education or all three.

There are very few studies of educational outcomes from interventions based on multisensory rooms [19-20]. Martin et al [21] pointed out that large portion of the studies evaluating the use of multisensory rooms were anecdotal and descriptive, some studies were poorly designed and gave no control conditions, and more carefully designed studies did not provide convincing evidence to support the advantages of multisensory rooms.
as a treatment. Many of the earlier studies, as well as being descriptive and with small sample sizes, focused on adults, not on children or young people, or on the children in institutions [18]. Therefore, the present study was planned to examine the impact of training of gross and fine motor function based on using visual stimulation modalities inside the sensory room in spastic cerebral palsied children with CVI.

**Materials and Methods**

A randomized clinical trial was conducted between May 2014 and December 2015 in pediatric outpatient clinic of the Faculty of Physical Therapy, Cairo University. A written informed consent form giving agreement to participation and publication of results was signed by the children’s parents. The study was approved by the ethics committee of the Faculty of Physical Therapy, Cairo University, Egypt.

**Subjects**

One hundred children with spastic CP, from both sexes, with ages ranged from two to four years, were recruited from the outpatient clinic of the Faculty of Physical Therapy, Cairo University; and Abu-El-Rish pediatrics hospital, Egypt.

Children were enrolled in this study if they had the following criteria: cortical visual impairment (CVI) with intact anterior visual pathway as demonstrated by intact light reflex, level 1 or level 2 of visual function according to Hoyt’s levels of visual function [5], a mild to moderate degree of spasticity; ranged from grade 1+ to grade 2 according to the Modified Ashworth Scale (MAS) [22], a developmental delay in their gross and fine motor skills, and ability to follow very simple verbal commands,

The presence of cortical visual impairment in spastic CP children and the level visual function was examined by an ophthalmologist, after the examination, 32 children were determined to have CVI. Three parents denied the participation of their children in this study. The visual function of the remaining 29 children, according to Hoyt’s levels of visual function, was as follows: nine children with CVI had visual function of level 1 and twenty children with CVI had visual function of level 2.

Children were excluded from this study if they had: damage to the optic nerve or the anterior portion of the eye, seizure, hearing problems/deafness, fixed contractures or deformities in the spine, upper or lower extremities, concurrent therapy with oral antispastic drugs, previous treatment with botulinum toxin injection, alcohol or phenol in the last six months before starting this study, previous neurological or orthopedic surgical interventions.

The subjects were randomly assigned into two equal groups (group I and group II) using a computer-generated random number list. Children in group I (control group) received the conventional physical and occupational therapy program in normally lighted room. Children in group II (study group) received the same physical and occupational therapy program given to group I using visual stimulation modalities in the sensory room.

**Instrumentation**

**For evaluation:**

a) Hoyt’s levels of visual function was used to determine the level of visual function before starting the treatment (Table 1).

b) Modified Ashworth scale was used to assess the level of spasticity before starting the treatment.

c) Gross Motor Function Measure (GMFM) is a standardized observational instrument designed and validated to measure the change in gross motor function over time in children with CP [23]. The GMFM test incorporates 88 items grouped in five dimensions: (a) Lying and Rolling; (b) Sitting; (c) Crawling and Kneeling; (d) Standing; and (e) Walking, Running and Jumping. Each item of the test is scored on a 4-point scale and percentage score is calculated for each dimension. The total score is obtained by calculating the mean of the five dimension scores. GMFM is applied according to the user’s manual [24]. In this study, GMFM was used to evaluate the gross motor skills (lying and rolling, and sitting) before starting and at the end of treatment program.

d) Peabody Developmental Motor Scale (PDMS) provides a comprehensive sequence of gross and fine motor skills, from which the therapist can determine the relative developmental skills level of a child, recognize the skills that are not totally developed and arrange an instructional program to develop those skills [25]. In this study, PDMS was used to evaluate the fine motor skills before starting and at the end of treatment program.
Table 1: Hoyt proposed system for evaluating a child’s visual abilities

<table>
<thead>
<tr>
<th>Visual level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The child could only perceive light at the time of the examination.</td>
</tr>
<tr>
<td>2</td>
<td>The patient could occasionally visually fixate on large objects, faces or movement in the environment.</td>
</tr>
<tr>
<td>3</td>
<td>If visual function as highly variable, but with at least some moments of good visual fixation as indicated by: (a) the ability to see small objects such as coins or stickers or (b) could reliably visually fixate a face</td>
</tr>
<tr>
<td>4</td>
<td>If a patient could reliably fixate on small targets and/or with visual acuity that could be measured in the range of 6/36 – 6/60</td>
</tr>
<tr>
<td>5</td>
<td>If there was a good reliable fixation and/or with visual acuity (measured under binocular viewing conditions) of 6/18 – 6/36</td>
</tr>
<tr>
<td>6</td>
<td>If there was a completely normal sensory visual examination</td>
</tr>
</tbody>
</table>

(Hoyt, 2003) [5]

For treatment:

- Sensory room is a special environment designed to develop individuals’ sense, more often through special lighting, music, and objects [26]. The sources of sensory stimulation provided can range from cheap, home-made effects from, for instance, foil, mirrors, scented oils, recorded music and textured materials to complex electrical equipment such as projectors, bubble tubes, fibre-optics vibrating devices, aroma diffusers and sound equipment [18-27]. In this study, the equipments used for visual stimulation, during training of gross motor skills were:
  - Bubble Tube (column): It is a vertical column having an extensive variety of various colors and filled with air and water. A small ball or toy can be added for more visual stimulation. When bubble tube is switched on the lights will sequence automatically through four colors and the bubbles will operate continuously. The tube has a color controller through it the colors can be changed.
  - Mirror ball: It provides a fascinating pattern of multiplied spots across the room with very slow movement. It is usually mounted from ceiling close to the corner of the room.

- Infinity Tunnel: It is a square shaped box with one raw of lights and encompassed by mirror. It gives impression of hundreds of spots of light disappearing out of view.
- Pin Wheel Projector: It projects colors and shapes like flowers, butterflies or stars onto surfaces.
- Ultra Violet Light / Black Light: it is also known as UV and black light. It is a highly visual medium that encourages concentration and provides visual challenges and promotes participation.
- Torches.

b- Mats, wedges, rolls and medical ball were used for conducting the physical therapy program.

c- Light toys, cubes and toys of different colors and shapes were used for the training of fine motor skills (occupational therapy program).

d- A table and chair with adjustable height, back support and belt.

Procedures

Evaluative procedures:

- Medical evaluation was carried out for all children participated in this study before starting the treatment program including: a) Magnetic Reasoning Image (MRI) to determine the site and extent of brain damage; b) complete ophthalmic examination (Fundus and Visual Evoked Potential tests); and evaluation of degree of visual function by Hoyt’s levels of visual function scale to quantify the degree of visual functioning (Table 1).
- Spasticity was evaluated using MAS to quantify the degree of spasticity for all children in both groups. The degree of spasticity ranged from grade 1+ to grade 2 according to MAS. To accommodate the “1+” modification for numeric analysis, grade “1+” was recorded as 1.5 [28].
- Motor functions were evaluated for all children (in both groups) prior to the commencement of training and at the end of the three months training period (post-treatment) by the same examiner who was blinded to which group each child was assigned. Gross motor skills were evaluated by GMFM scale. In the current study, dimensions ‘A’ and ‘B’ of GMFM were used to assess lying & rolling and sitting which were determined as a goal area for the GMFM. This valid, reliable and sensitive test was applied in accordance with the manual’s detailed [23-24]. Fine motor skills were evaluated by PDMS. Grasping and visual motor integration.
subtests were evaluated. After administration of all tests in each subtest, raw and standard scores were calculated for each one. Finally, fine motor quotient was determined, as it was derived from the standard scores of the two subtests.

Treatment procedures:
The same occupational and physical therapy program was given to all children in both groups for two and half hours, three sessions per week for successive three months. Children in group I (control group) received this program in ordinary lighted room, while those in group II (study group) received the same program in the sensory room using all visual stimulation equipments during the training of fine and gross motor skills.

Occupational therapy program
Training of fine motor skills (types of grasp, the pattern of reach and the pattern of release) was applied to all children in both groups for one hour per session (three sessions / week) over a period of three months. For group I, the fine motor skill training program was applied in the ordinary lighted room, while for group II, it was applied in sensory room using light lines to change the color of the whole room or using light toys in a complete dark room. The exercises were applied while the child in supine and/or supported sitting position according to the motor abilities of each child. The therapist guided and assisted the child to perform the following training:
- Training of reaching that included reach for an object presented at midline with each hand, reach with 45° and 90° of shoulder flexion and neutral rotation of humerus from supine position and finally reaches across midline while keeping an erect trunk in sitting position.
- Use a sustained palmer grasp with wrist extension either grasping an object like a rattle or cube from supine or sitting or maintained grasp on bars, handles, in front, at the side, above or below the child in sitting position.
- Training of grasp with finger tips opposed to the thumb, then grasp smaller object with the tips of index and thumb (precise pincer grasp) (if possible).
- Release objects like cubes into a defined area or container with different sizes and at different distance from the child then release smaller objects like pellets into cup and progress to small bottle (if possible).
- Use both hands together to clap, bang two cubes, or to push and pull an object.

After a 60-minute rest period, the traditional physical therapy program was applied for all children in both groups.

Physical therapy program
All children in both groups underwent a one and half hour traditional physical therapy exercise session (three sessions / week) over a period of three months. This program included Neurodevelopment technique (NDT) that was focused first on correcting abnormal tone, encouraging normal motor patterns, and positioning [29]. Hand weight bearing (HWB) exercises for both upper limbs, as proprioceptive training, were also applied from positions of sitting or side sitting on a mat and/or sitting on a roll. Additionally, protective extensor thrust (PET) was provided from sitting on a roll and prone on a ball to stimulate the extensor pattern of the upper limbs. Manual passive stretching exercises to restore flexibility of tight muscles (ankle plantarflexors, knee and hip flexors, hip adductors, flexors of fingers, wrist and elbow, forearm pronators and shoulder adductors and internal rotators), which was based on the passive range of motion (PROM) therapeutic exercises described by Kisner and Colby [30], were also part of the routine training program. Furthermore, all children in both groups received the following exercises to improve the control of head, trunk, rolling and sitting with the therapist guidance and assistance for the children to perform each exercise correctly.
- In prone position, across a roll or ball, a) elevating the child’s arms gently and encouraging the child to raise his/her head and trunk up, b) rocking the child forward and backward, and c) rhythmical taping was applied under the child’s chin or forehead to assist him/her to lift the head. From prone over a wedge, encouraging the child to raise his/her head and trunk and weight bearing on forearms or hands.
- In supine position, the child was allowed to grasp a bar or the therapist’s hand with one hand and he/she was encouraged to get to sitting in a diagonal direction and support on his/her opposite hand.
- In sitting position, on a back supported chair, the child’s shoulders were supported and holding the head in midline with eye-to-eye contact was encouraged. Sitting on mat with one hand supported then with both hands free, try to reach an object with one hand. From sitting position on roll or ball, facilitation of trunk
rotation, righting, protective and equilibrium reactions were applied.
- Rolling exercises, the child was encouraged to roll from supine to prone over his/her right side and then from prone to supine position again. The same exercise was repeated over the left side.

For group II, all the previously mentioned exercises were conducted using visual stimulation modalities inside the sensory room. Those stimulations included; displaying moving pictures from projector, spotlights from torch and mirror ball on the wall and/or on the ground, changing the shading and moving water inside the bubble column, distinctive line of lights inside infinity tunnel. These visual stimulations were used from different positions (supine, prone and sitting) to motivate and encourage the child to take an interest and participate efficiently for long period of time.

**Statistical analysis**

Statistical analyses were performed using SPSS software package (version 20.00). Descriptive statistics of mean and standard deviation exhibited the children’s ages, visual level, MAS scores, fine motor quotient (FMQ), GMFM scores of lying and rolling, sitting and goal total. Non-parametric tests were utilized to analyze the results of FMQ and GMFM scores within and between the groups. Wilcoxon signed rank test was used to detect differences between before and after the training program in favor of group II (P = 0.001) (Table 3). The analysis of GMFM scores values pre- and post-treatment between the groups, using the Mann–Whitney test, revealed none significant difference in pre-treatment results of dimensions “A” (P = 0.836) and dimension “B” (P = 0.918) and goal area (P = 0.797), but, statistical significant difference was found between both groups after training period in favor of group II (P = 0.000) in both dimension (A & B) and goal area (Table 4).

**Fine motor skills**

The Peabody Development Motor Scale was used to evaluate the fine motor skills for children in this study. Fine Motor Quotient (FMQ), which is the most reliable score yielded by this scale, was used to measure the changes in fine motor function (grasping and visual motor integration) after our intervention.

When comparing the pre- and post-treatment values of FMQ within each group, using the Wilcoxon test, revealed none significant improvement in group I (P = 0.15) as only three children in this group was improved with no change in the remaining ten, while a significant improvement was gained in group II (P = 0.001) (Table 3). The analysis of FMQ values pre- and post-treatment between the groups, using the Mann–Whitney test, revealed none significant difference in pre-treatment results (P = 0.6), while statistical significant difference was found in the post-treatment results in favour of group II (P = 0.035) (Table 4).
Table 2. Demographic characteristics of participants in both groups

<table>
<thead>
<tr>
<th></th>
<th>Group I (n=13)</th>
<th>Group II (n=13)</th>
<th>T-value</th>
<th>Z-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>31.8 ± 4.6 a</td>
<td>32.38 ± 5.25 a</td>
<td>-0.277 d</td>
<td></td>
<td>0.784*</td>
</tr>
<tr>
<td>MAS b</td>
<td>1.8 ± 0.25 a</td>
<td>1.84 ± 0.24 a</td>
<td>-0.404 e</td>
<td></td>
<td>0.686*</td>
</tr>
<tr>
<td>Visual level</td>
<td>1.69 ± 0.4 a</td>
<td>1.61 ± 0.5 a</td>
<td>-0.404 e</td>
<td></td>
<td>0.686*</td>
</tr>
<tr>
<td>Type of CP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diplegia</td>
<td>8 (61.54%)</td>
<td>9 (69.23%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadriplegia</td>
<td>5 (38.46%)</td>
<td>4 (30.76%)</td>
<td></td>
<td></td>
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<tr>
<td>Gender c</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Girls</td>
<td>5 (38.46%)</td>
<td>6 (46.15%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>8 (61.54%)</td>
<td>7 (53.85%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Values are mean ± standard deviation, b Modified Ashworth scale, c Frequency percentage, d Independent t-test, e Z: Mann-Whitney Test value, *Significant at p < 0.05

Table 3. Statistical analysis of dimensions 'A' and 'B' and goal area scores of GMFM and FMQ of PDMS-2 within group

<table>
<thead>
<tr>
<th>Test /Group</th>
<th>Pre</th>
<th>Post</th>
<th>Z-value</th>
<th>P-value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMFM Scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimension A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group I</td>
<td>17.03 ± 6.06 a</td>
<td>20.50 ± 6.58 a</td>
<td>-3.225</td>
<td>0.001</td>
<td>Sig</td>
</tr>
<tr>
<td>Group II</td>
<td>16.43 ± 5.28 a</td>
<td>32.42 ± 5.97 a</td>
<td>-3.218</td>
<td>0.001</td>
<td>Sig</td>
</tr>
<tr>
<td>Dimension B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group I</td>
<td>11.27 ± 3.61 a</td>
<td>13.59 ± 3.78 a</td>
<td>-3.205</td>
<td>0.001</td>
<td>Sig</td>
</tr>
<tr>
<td>Group II</td>
<td>11.03 ± 3.16 a</td>
<td>24.35 ± 4.63 a</td>
<td>-3.193</td>
<td>0.001</td>
<td>Sig</td>
</tr>
<tr>
<td>Goal Area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group I</td>
<td>14.15 ± 4.78 a</td>
<td>17.04 ± 5.12 a</td>
<td>-3.192</td>
<td>0.001</td>
<td>Sig</td>
</tr>
<tr>
<td>Group II</td>
<td>14.54 ± 4.40 a</td>
<td>28.38 ± 5.13 a</td>
<td>-3.184</td>
<td>0.001</td>
<td>Sig</td>
</tr>
<tr>
<td>PDMS Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMQ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group I</td>
<td>46.92 ± 1.44 a</td>
<td>47.61 ± 1.98 a</td>
<td>-1.414</td>
<td>0.15</td>
<td>Non-Sig</td>
</tr>
<tr>
<td>Group II</td>
<td>47.38 ± 1.98 a</td>
<td>57.76 ± 3.11 a</td>
<td>-3.272</td>
<td>0.001</td>
<td>Sig</td>
</tr>
</tbody>
</table>

Dimension A: Lying & Rolling, Dimension B: Sitting, FMQ: Fine motor quotient, Z: Wilcoxon Signed-Rank Test value, * Significant at p < 0.05

Table 4. Statistical analysis of dimensions 'A' and 'B' and goal area scores of GMFM and FMQ of PDMS-2 between groups

<table>
<thead>
<tr>
<th></th>
<th>Pre treatment</th>
<th>Post treatment</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Z-value</td>
<td>P-value</td>
<td>Z-value</td>
</tr>
<tr>
<td>GMFM Scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimension A</td>
<td>-.207</td>
<td>0.836</td>
<td>-3.551</td>
</tr>
<tr>
<td>Dimension B</td>
<td>-0.103</td>
<td>0.918</td>
<td>-3.985</td>
</tr>
<tr>
<td>Goal Area</td>
<td>-0.257</td>
<td>0.797</td>
<td>-3.744</td>
</tr>
<tr>
<td>PDMS Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMQ</td>
<td>-0.524</td>
<td>0.600</td>
<td>-4.424</td>
</tr>
</tbody>
</table>

Dimension A: Lying & Rolling, Dimension B: Sitting, FMQ: Fine motor quotient, Z: Mann-Whitney Test value, * Significant at p < 0.05

Abd El-Maksoud et al., International Journal of Therapies and Rehabilitation Research, 2016; 5 (4): 265-277
Discussion

Vision has a central role in the development of many functions. The most important functions that are related to development of vision during the first year are: communication and early interaction, motor development, body awareness, object permanence, language, development of spatial concepts and orientation in space [31]. Children with vision impairments and developmental delay need increment stimulation and interaction based on their residual vision [14].

Persha [32] accentuated the advantages of utilizing visual stimulation modalities as they encourage visual skills of clients at numerous levels of understanding and learning such as visual processing and discrimination, visual perception, visual input, focus, concentration, eye exercises, tracking, awareness, increasing hand-eye coordination, encouraging participation and social skills, and providing visual challenges.

To date, few studies were conducted on children with CVI. Most of these studies highlighted cognitive visual dysfunction in those children with CVI [33] and low vision at school age [34]. In any case, there is lack of researches concerning motor functions in young children having multiple disabilities and CVI like CP children with CVI. Moreover, there has been limited researches on the impacts of multi-sensory environments (MSEs) or rooms and snoezelenand especially in relation to the consequences for children. Reviews of researches on MSEs recognized few studies reporting the impacts on children with disabilities who received intervention in small groups, as commonly happens in schools [35]. So, the present study was conducted to investigate the effect of visual-based training program for gross and fine motor skills using visual stimulation modalities inside the sensory room on improving motor functions in spastic cerebral palsied children with CVI.

It was planned in this study to choose the age of the study sample to be ranging from two to four years. This comes in agreement with the opinion of Dutton [36] who stated that if there is any suspicion of CVI, intervention should begin immediately, the first few years of life are a ideal time for learning how to utilize vision especially with young children with CVI. By beginning early, one can really enhance the child’s visual prognosis.

In the present study, children in both groups obtained low scores in A and B dimensions of GMFM and FMQ of PDMS before treatment. These outcomes demonstrated that spastic CP children with CVI have delay in the development of both gross and fine motor functions. These findings are supported by Morse [10] who reported that those infants and children with CVI are delayed to a greater or lesser degree in achieving developmental milestones and in all sensory-motor activities and social development. Direct intervention and stimulation at an early age and providing support for caregivers are essential particularly in the early years.

The results of current study showed a significant improvement of gross motor skills including lying & rolling and sitting dimensions of GMFM in both groups, however, higher improvement was achieved in group II. Regarding fine motor skills, none significant improvement was seen in group I, however significant improvement was obtained in group II after three months of treatment.

The significant improvement of gross motor skills in the both groups might be attributed to the designed physical therapy exercise programme. This program was focused on controlling spasticity, encouraging normal motor patterns, increasing the ability to support on upper extremity, improving equilibrium and balance and maintaining the flexibility of muscles of extremities. On the other hand, the programme was directed to improve the control of head and trunk through different exercises on ball, roll and mat, to encourage active rolling on mat. Moreover, the programme was concentrated on positioning the child in sitting with, and also to change his position from supine to sitting.

The improvement of gross and fine motor skills for children in group II might be attributed to training of those skills inside the sensory room using visual stimulation modalities. Multi-sensory environments (MSEs) or rooms are used to provide passive stimulation and opportunity for the child to relax and explore, as per the original snoezelen philosophy. The real results of this stimulation remain vague but have included such things as an increase in attention span, improved sensory and motor development, communication skills and improved quality of life. The MSE also provides a context for teaching a range of skills that that could likewise be taught in different situations, as communication skills and switch use. Claims were also made for the calming of children exhibiting challenging behaviour and for reduction in stereotypic behavior [37].

The finding of this study is supported by opinion of longhorn [38] who focused on creating a multi-sensory environment for children with a visual impairment and complex needs. The earliest levels of stimulating vision through using materials that offer light and dark, movement and very vivid colors which are the first stages.
in stimulating vision in order to look with understanding. There are additionally ranges of very stimulating moving pictures that are attractive to the brain, which appear to have strong vibratory properties. The room has everything the child needs to improve his/her experience of vision, light and color, and the environment around us with lots of various impacts.

Caliket al [34] examined the effectiveness of a 6-week attention training program in children with low vision. Their study included 20 children with low vision, aged 7–12 years. The children were divided into 2 groups. While the first group participated in a 6-week Pay Attention training program 3 times a week for 30 min, the second group was the control. They found that the attention training program improves cognitive function, independence in activities of daily living, and the quality of life of children with low vision.

For many children with CVI, reaching out and actively participating is a frightening experience to them; the world may seem chaotic and unfriendly. The environments in which these children function, the activities in which they engage, the sensory-motor demands of tasks, time pressures, child's attention and interfering variables should be examined before intervention [39-40]. Some children increase their visual awareness by such means as the use of lighted toys in a darkened room, the light box, distinctive geometric patterns, the use of bright colors, and sound toys [6].

Conducting the occupational and physical therapy program inside the sensory room for children in group II may be the main reason of higher scores of GMFM and FMQ picked up in this group. A sensory room could attract children to participate more actively and effectively for a long period of time during training through providing material that were visually motivating and attractive: light toys, bright lights, shapes and patterns and the showing of material were near to the child and in a position where we expected optimal reaction. In addition, sensory room is quite simple, place where the distractions of the outside world are completely absent; present the children with drawing attention to the task of training.

Selecting the sensory room as an environment in which the training program was applied for children in group II is supported by Persha [32]. He mentioned that working in a darkened environment with light can make it easier both for the pupil to become aware of a particular stimulus. It is thought that people with CVI have difficulties in perception, which means they have difficulty in picking out and recognizing individual characteristics. Perception of light is the most basic of visual perceptions and without it no other vision can develop.

Training of fine motor skills for children in group II was likewise conducted inside sensory room using light lines to change the color of the whole room or using lighted toys in a complete dark room. This environment and light toys improved visual skills, increased attention and concentration for those children which are essential for development of fine motor skills. This interpretation is affirmed by the opinion of Hyvarinen [41] who stated that sensory lights for children enhance concentration, promote participation and visual stimulation through flashing lights, torches, fiber optics and glow in the dark. The sensory lights for children provide visual challenges, eye-catching fun that inspires visual input and development. Sensory lights for children are ideal for visual processing, improving tracking and increasing eye-hand coordination.

The results of this study are supported by the findings of Malkowicz et al [14]. They examined the effect of an intensive visual stimulation program retrospective on a fairly homogeneous group of 21 children with CVI due to perinatal hypoxic-ischemic injuries or postnatal anoxia who had multiple neurological deficits. Each subject underwent an at-home treatment program. Twenty of 21 children (95%) manifested significant improvement after 4 to 13 months on the program. Results indicate that visual stimulation programs make use of daily occurrences of random stimulation, increase the daily occurrences, and purposefully provide the brain with a chance to form the appropriate connections in order for visual recovery to occur. It can be seen that visual stimulation programs improve a brain-injured child's ability to see significantly more than that of an individual not receiving visual stimulation.

In respect to this study, training of gross and fine motor skills for children in group II based on utilizing movable lights, pictures and toys more than stationary ones or using bright color lights in a complete dark room to fill the child's visual field. Anthony [42] reported that children with CVI can frequently find moving stimuli with greater speed and accuracy, as well as maintaining attention to moving stimuli for a longer period of time. Moreover, filling the visual field is very essential when dealing with children who suffer from CVI that may be achieved through close viewing, picture enlargement, moving objects from the peripheral field of vision and progress to more central fields.

In the current study, using visual stimulation modalities in form of light toys, movable shapes and pictures was considered as pleasing and lovely for the child.
to play and practice exercises. Such environment motivated and engaged children so that, they became more focused or made greater efforts to attempt motor activities. Powell [43] Parham and Primeau [44] and Case-Smith [45] highlighted the importance of playing for the development of motor skills in children. They reported that an intervention mode and play activities maintain the child’s attention, interest and energy for the task. Whenever playing, the child also experiences joy and fun, and therefore associates positive influence with the activity; in this manner, the skills linked with play are generalized and it is likely to be practiced in different situations. Since play incorporates affective, social, emotional and cognitive components, it gives a chance for the child to integrate new skills into his or her repertoire daily behaviors.

In a normally-lit environment, it might be extremely hard to pick out or see a small light source, even when it is moving. Light does not have the additional characteristics of objects, i.e.; three dimensions and in order to use its properties more effectively we need to make it emerge in a dark room can help greatly with this. Indeed, even a penlight torch appears to be much brighter in darkened surroundings. Sometimes, just the fact of being in a different environment makes the individual more alert, fascinated and curious [32].

Lack of significant changes in fine motor skills for children in group I, may be related to the environment and the materials in an ordinary lighted room. This mode of intervention didn’t give a chance for the child to experience the best visual experiences to augment visual attention and to participate efficiently in visual-motor activities throughout the training. Furthermore, it is troublesome for those children to distinguish the objects even with different colors and shape when presented to them and need extended periods of time to exhibit a visual reaction and take part in activities. This clarification is supported by Morse [39] and Anthony [42] who reported that students with CVI will require extra time to comprehend approaching visual data and to perceive designs in what they see. Likewise, this view comes in coincidence with palmer [46] who stated child may pretend a delay in using vision to “look at” a target most of the time when a new item is displayed or a new activity begins.

There were some limitations of this study. The small number of participants might limit the generalization of the study outcomes. Three months of training that the two groups received was considered short period for treatment for such cases. Moreover, lack of follow-up for the children in both groups might be considered another limitation of the study. Follow up assessment for very few children (only for 5 children) was done after 6 and 9 months, but their data was not taken in this study. Therefore, further studies will be needed to evaluate the effects of visual stimulation program training for long duration and on a larger sample size.

Conclusion

The present study demonstrates the valuable effects visual stimulation based program in spastic CP children with CVI. Training of gross and fine motor skills using visual stimulation modalities inside sensory room is effective for those children to improve their gross and fine motor functions. It can be concluded that early intervention and appropriate training for young CP children with CVI has been shown to enhance motor functions significantly and minimize the problems associated with these disorders. Long-term follow-up studies and further investigations into the benefits of using sensory room on cognitive problems in those children will be needed. Further studies are recommended to target different ages of CP children with CVI to enable comparisons of the results across different age groups.

Acknowledgements

The authors want to express gratitude toward Dr. Kamal E. Shoukry, Professor of physical therapy for pediatrics, faculty of Physical Therapy, Cairo University for his continuous help and support during conducting the practical part of this study, for showing keen interest in this study providing a constructive criticism, valuable guidance. Also, all authors would like to express their thankfulness to every one of children and their parents for their co-operation and participation in this study. Great thankful to all physical therapists at the outpatient clinic of faculty of Physical Therapy, Cairo University and Abu El-Rish pediatrics’ hospital for their continuous help and collaboration in the enrolment of children and information obtaining in this study.

Conflict of interest

The authors proclaim that there is no conflict of interest in this study.
Funding

This research received no specific grants from any funding organization in the public, commercial, or non-profit sectors.

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