Task-Specific Motor Training in Children with Fetal Alcohol Syndrome

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Tara Walter  Joshua Vaughn  Edilberto A. Raynes

Abstract

Fetal Alcohol Syndrome (FAS) is a disorder manifested among children whose mothers consumed alcohol during gestation. Symptoms of this disorder are varied, but specifically affect neurodevelopmental status. In FAS, the diminished motor control does not improve throughout life, which warrants early intervention. Several studies suggest using task-specific motor training interventions in children with motor development delays to increase their ability to perform motor tasks. Using verbal and visual cues in conjunction with motor training has been proven to improve motor skills among children with motor developmental delay. There has been no evidence-based literature that evaluates the use of interventions to increase motor skills in the FAS population. Using Oxford Levels of Evidence, the authors explored the literature on increasing motor skills and developed a physical therapy intervention that will improve the quality of life of children affected by FAS. It was concluded that using a reach and grasp program should help to increase hand-eye coordination in children with FAS.

Keywords: fetal alcohol syndrome, children, motor skills, motor learning, motor development, motor coordination, physical therapy, motor delay, poor coordination, central nervous system, motor feedback, dexterity, fine motor skills, gross motor skills

Introduction

Fetal Alcohol Spectrum Disorder (FASD) is a spectrum of disorders due to alcohol exposure in utero, which leads to impaired growth, central nervous system (CNS) dysfunction, and birth defects. This spectrum includes diagnoses of Fetal Alcohol Syndrome (FAS), Partial FAS, and Alcohol Related Neurodevelopmental Disorder (ARND), all of which require confirmation of maternal alcohol exposure and neurodevelopmental problems (Peadon, Rhys-Jones, Bower, & Elliot, 2009). Among the FASD, FAS is the most severe form (Centers for Disease Control and Prevention [CDC], 2011). It is defined as a cluster of abnormalities in children whose mothers chronically consumed high doses of alcohol during pregnancy (Jones & Smith, 1973). Also, it causes cognitive, sensory, motor control (fine and gross), and executive function deficits (Jirikowic, Olson, & Kartin, 2008). Damage to the CNS, specifically to the cerebellum, is associated with fetal alcohol exposure. This exposure causes decreased motor function (Klintsova et al., 2002). Additionally, children with prenatal alcohol exposure have a decreased size of their corpus callosum, which leads to decreased signal transmission between the hemispheres of the brain, leading to decreased bimanual coordination (Willford, Chandler,
Goldschmidt, & Day, 2010).

There are three criteria for diagnosing FAS: documentation of growth deficits, CNS abnormality, and facial abnormalities. In addition to the diagnostic criteria, the CDC outlines six functional domains: cognitive or developmental deficits, executive functioning deficits, motor functioning delays, attention or hyperactivity problems, problems with social skills, or ancillary problems such as sensory, pragmatic language, or memory deficits. In accordance with the CDC, children receive the diagnosis of FAS if they are deficient in at least three of the six domains (CDC, 2011). Research has revealed that there are distinct physical features associated in children with FAS such as a thin upper lip, a flat or smooth philtrum, short palpebral fissures, and a flat midface (Burden et al., 2009).

Much of the research discusses motor training in children with Developmental Coordination Disorder (DCD). DCD is a chronic and usually permanent condition, which is characterized by motor impairment that interferes with the child’s activities of daily living and academic achievement (Barnhart, Davenport, Epps, & Nordquist, 2008). The clinical manifestations include decreased attention, motor function, and perception. Each of these signs and symptoms parallel with the deficits associated with FAS (Hillier, 2007; Jirikovic, et al., 2008). The majority of the literature discusses motor problems associated with DCD and motor training, but there is a dearth of literature discussing task specific motor training in children with FAS. The literature does indicate that neuromotor task training (NTT) increases motor function in children with DCD, and research has shown that children with DCD exhibit similar motor deficits as children with FAS (Hillier, 2007; Jirikovic, et al., 2008). Therefore, it can be inferred that NTT can be employed as an intervention to improve motor deficits associated with FAS.

**Research Question**

Evidence has shown that physical therapy can increase motor skill abilities in children by introducing different interventions (Burden, et al., 2009). The researchers sought to determine if physical therapy will increase the motor skills of children with FAS. The research question was: Will the implementation of a task specific training program, like reach and grasp, increase hand-eye coordination and hand dexterity in children with motor deficits associated with FAS?

**Materials and Methods**

The sources reviewed included the Academic Search Premier, EBSCOHost, Google Scholar, and PubMed databases, and Physical Therapy Journal. Keywords used were fetal alcohol syndrome, children, motor skills, motor learning, motor development, motor coordination, physical therapy, motor delay, poor coordination, central nervous system, motor feedback, dexterity, fine motor skills, gross motor skills, movement training. The inclusion criteria were as follows: articles focusing on developmental delays and using motor training. One hundred and three articles related to the topic were found; 22 were reviewed, based on their higher level of evidence.

The Oxford Centre for Evidence-Based Medicine Levels of Evidence (OCEBMLE) was used to search for articles. Table 1 provides more detailed information regarding the OCEBMLE.

**Results**

Table 2 summarizes articles that were reviewed by the researchers. The table is arranged from highest level of evidence to the lowest, based on the OCEBMLE. Key points of articles are also provided.
<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
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<tbody>
<tr>
<td>1a</td>
<td>Systematic Review of RCTs</td>
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<tr>
<td>1b</td>
<td>Individual RCT (with narrow Confidence Interval)</td>
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<td>1c</td>
<td>All or none RCT</td>
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<tr>
<td>2a</td>
<td>Systematic Review of cohort studies</td>
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<tr>
<td>2b</td>
<td>Individual cohort study (including low quality RCT; e.g., &lt;80% follow-up)</td>
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<td>2c</td>
<td>&quot;Outcomes&quot; Research; Ecological studies</td>
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<tr>
<td>3a</td>
<td>Systematic Review of case-control studies</td>
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<td>3b</td>
<td>Individual Case-Control Study</td>
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<td>4</td>
<td>Case-series (and poor quality cohort and case-control studies)</td>
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<td>5</td>
<td>Expert opinion</td>
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Updated by Jeremy Howick in March 2009; modified from the original [http://www.cebm.net/?o=1025](http://www.cebm.net/?o=1025).
<table>
<thead>
<tr>
<th>Article Title</th>
<th>Level of Evidence</th>
<th>Date of Study</th>
<th>Purpose</th>
<th>Population</th>
<th>Conclusion/Results</th>
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<tr>
<td>Therapeutic effects of complex motor training on motor performance deficits induced by neonatal binge-like alcohol exposure in rats: A quantitative stereological study of synaptic plasticity in female rat cerebellum</td>
<td>1</td>
<td>2002</td>
<td>To gather quantitative data regarding the neuroplasticity of the paramedian lobule in the cerebellum of rats exposed to alcohol after a 20 day motor training program.</td>
<td>Forty-four rats were divided into control groups and alcohol exposure groups, while some participants received motor training and others did not.</td>
<td>Motor training caused neuroplasticity of the cerebellum after alcohol exposure and cerebellar damage, which proves the ability to improve cerebellar function.</td>
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<td>Motor response programming and movement time in children with heavy prenatal alcohol exposure</td>
<td>1</td>
<td>2010</td>
<td>To examine the effect a history of prenatal alcohol exposure has on response programming.</td>
<td>Children ages 7 to 17 were recruited from the Center of Behavioral Teratology at San Diego; 28 were placed in the alcohol exposed group and 22 in the control group.</td>
<td>The fetal alcohol syndrome group produced considerably slower reaction times, when a movement was required, and movement times, but the group who were categorized in the exposure group did not.</td>
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<td>Neuromotor task training for children with developmental coordination disorder: A controlled trial</td>
<td>1</td>
<td>2012</td>
<td>To determine if neuromotor task training improves motor performance in children with developmental coordination disorder along with examining the impact of behavioral characteristics on success from treatment.</td>
<td>The treatment group included 20 males and 6 females, ages 2 months to 7 years w/ developmental coordination disorder; the control group included 10 males and 2 females, ages 2 months to 7 years.</td>
<td>The hypothesis was confirmed; it can be assumed that neuromotor task training is successful in improving task-oriented skills in children with developmental coordination disorder.</td>
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<td>Task-specific intervention with children reduces movement problems</td>
<td>1</td>
<td>1993</td>
<td>To determine the effects a task-specific intervention program would have on uncoordinated</td>
<td>Twenty-four children, who were determined to be un-coordinated via a checklist, were recruited from</td>
<td>Task-specific interventions improved kicking, throwing, and bounce-catch tasks for children with poor coordination.</td>
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<td>Study Title</td>
<td>Year</td>
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<td>Results/Results</td>
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<td>Motor control and the management of musculoskeletal dysfunction</td>
<td>2006</td>
<td>To discuss the feed forward mechanism, cortical plasticity, and task-specificity associated with motor control. Implications were reviewed for patients with musculoskeletal dysfunction within clinical practice settings.</td>
<td>This systematic review does not have a specific population but instead focuses on three motor control concepts from various studies including random control trials. Feed forward mechanisms were discovered as vital components of motor control. Neuroplasticity can allow for cortical reorganization following injury through task-specific motor training. Practice of whole task functional activity with variations in environment should provide the most susceptible learning experience for rehabilitation.</td>
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<td>Research-based interventions for children and youth with a fetal alcohol spectrum disorder: Revealing the gap</td>
<td>2006</td>
<td>To determine the most effective interventions for children from birth to 18 years of age, with diagnosed FAS or FASD.</td>
<td>All studies included between 4-12 participants ages from birth to 18 years old, a diagnosis of FAS or FASD, and lasted between 3 days and 10 months. The authors emphasized the importance of early interventions for children with FAS, since brain plasticity is greatest in early childhood. The studies focused on the medicinal and behavioral therapy associated with the condition.</td>
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<td>The role of task-specific training in rehabilitation therapies</td>
<td>2005</td>
<td>To describe task-specific motor training and constraint-induced movement therapy, beneficial treatment strategies which reorganize damaged cortical areas of the brain.</td>
<td>Various animal and clinical human cohort studies and random control trials. Repetitive low-intensity task specific activity produced the greatest functional improvement.</td>
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<td>The effects of fetal alcohol syndrome on response execution and inhibition: An event-related potential study</td>
<td>2009</td>
<td>To observe the degree of alcohol-related effects on response inhibition by recognizing differences in neural activation during task performance using event-related</td>
<td>The population included older siblings of the participants from the Cape Town Longitudinal Cohort Study and other participants, who were chosen by screening all Children with FAS/PFAS had slower and less efficient processing times and amplitude differences. The children who were exposed to alcohol showed more cognitive effort when measuring the level of neural</td>
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<td>Study Title</td>
<td>Year</td>
<td>Method/Participants</td>
<td>Findings</td>
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<tr>
<td>Effectiveness of neuromotor task training for children with developmental</td>
<td>2003</td>
<td>To determine the effectiveness of neuromotor task training on children with developmental coordination disorder.</td>
<td>Using neuromotor task training in children with developmental coordination disorder improved manual dexterity, ball skills, and handwriting quality.</td>
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<td>coordination disorder: A pilot study</td>
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<td>Nine male and 6 female children.</td>
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<td>Intervention for children with developmental coordination disorder: A</td>
<td>2007</td>
<td>To identify all intervention based research exploring the usefulness of defined approaches with children with developmental coordination disorder, identify the quality and levels of evidence for effectiveness, and convey the implications for management and future research.</td>
<td>Perceptual-motor therapy and sensory-integration therapies were shown to have a positive effect on children with developmental coordination disorder.</td>
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<td>systematic review</td>
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<td>Children of any age who had developmental coordination disorder (found by standard tests).</td>
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<td>Interaction of feedback frequency and task difficulty in children’s motor</td>
<td>2012</td>
<td>To examine the interaction of knowledge of results (KR) frequency and task complexity on the acquisition, retention, and transfer of a novel throwing skill in fourth and fifth grade children with typical development.</td>
<td>Clinicians teaching motor skills should design practice conditions in accordance with the cognitive processing capacity of the learner.</td>
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<td>skill learning</td>
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<td>Forty-eight children (31 male, 17 female; mean age 10.7 yrs) from fourth and fifth grade classes at a local community school.</td>
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<td>Effects of prenatal tobacco, alcohol, and marijuana</td>
<td>2010</td>
<td>To determine the effects of prenatal and current</td>
<td>Light to moderate prenatal alcohol, tobacco, and marijuana</td>
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<td>Three hundred twenty offspring (16-18 years old)</td>
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| Sensory processing, school performance, and adaptive behavior of young school-age children with fetal alcohol spectrum disorders | 2008 | To explore the sensory processing and sensory-motor function of children with diagnosed FASD in comparison to children with typical development.  
Twenty-five children diagnosed with fetal alcohol spectrum disorder and 26 children with typical development, all aged between 5-8 years old.  
Children diagnosed with fetal alcohol spectrum disorder had decreased function of sensory processing and sensory-motor operation compared to peers with typical development. |
| Motor learning in children: Feedback effect(s) on skill acquisition    | 2008 | To determine the effect of different relative frequencies of feedback on children’s skill learning when compared with young adults’ skill learning.  
Twenty young adults and 20 normally developing children.  
Children may need longer practice times (and reduce feedback more gradually) during motor learning than adults. |
| Effects of color stimulation on handwriting performance of children with ADHD without and with additional learning disabilities | 2003 | Researchers wanted to use a larger sample size that included a control group and ADHD children with learning disabilities and speech disorders to confirm previous findings of the qualitative aspects of handwriting.  
Forty-four boys with diagnosed ADHD.  
Stimulation using color has shown positive effects on increasing handwriting control in children with ADHD (and other learning disabilities). |
Discussion

After a thorough review of the articles, the authors identified and centered the discussion on the following common themes: task-specific training, motor coordination delay and DCD, and neuroplasticity.

Task-Specific Training

In a randomized control trial (RCT), Revie and Larkin (1993) found motor improvements in children with poor coordination after task specific training in target kicking, volleyball bounce catch, and overhand throwing. The intervention group performed the specific activities while the control group only performed impairment therapy and avoided doing task specific training. Since task-specific interventions are shown to cause improvements in children's motor capabilities, it can be argued that it would also increase the abilities of children with FAS. In children with DCD, Pless and Carlsson (2000) found through a meta-analysis study that a motor skill intervention was better than sensory integration and general abilities approach because transference of abilities was difficult for young children. Schoemaker et al. (2003) studied the effectiveness of NTT on children with DCD. The results revealed that there was a significant improvement in manual dexterity and ball skills after the treatment in the intervention group as measured by the Movement Assessment Battery for Children (M-ABC). There was also a significant improvement in handwriting quality in the intervention group as by the Concise Assessment Method for Children's Handwriting (Schoemaker, Niemeijer, Reynders, Bouwien, & Smits-Engelsman, 2003). Ayash and Preece (2003) looked at five treatment approaches for DCD: sensory integration, process oriented, perceptual motor training, task oriented, and cognitive approach. They argued that determining a specific treatment approach was problematic because the condition is continually changing. Using a task-specific approach was the best intervention because it focuses on the problem at hand, is cheaper, is less time-consuming, and is strongly supported by other studies. Bayona et. al. (2005) found similar results showing that low-intensity, repetitive task-specific training increases functional abilities.

Motor Coordination Delay and DCD

In a systematic review by Barnhart et al. (2008) it was discussed that DCD involves gross motor, fine motor, and psychosocial deficits. These motor skill deficits mirror the problems associated with FAS. Children with DCD have trouble with handwriting, drawing, gripping, and dressing, which is akin to FAS. The study found that higher incidence of DCD may be found among children with a history of prenatal or perinatal difficulties. From the study, a frequently used treatment for DCD was cognitive or problem-solving skills. The participant was required to select and implement the most appropriate strategies for successful task performance. This is called a task-specific intervention or cognitive orientation to ADLs.

In another systematic review, Missiuna et al. (2003) discussed secondary impairments that are common in children with DCD, such as the inability to manipulate small objects. They found that repetitive task-specific training in conjunction with verbal cueing and feedback was helpful in increasing motor function in these children. A systematic review by Hillier (2007) identified interventions based on research exploring the usefulness of defined approaches with children with DCD, identifying the quality and levels of evidence for effectiveness, and conveying the implications for management and future research. This research showed that perceptual-motor therapy and sensory-integration therapy were shown to have a positive effect on children with DCD, and reinforced the idea that training in specificity improves the performance of the task. Mak (2010) performed a case control study, and found that children with DCD have slower reaction and movement times and greater force when reaching and grasping a moving target than children of the same age who do not have DCD.

Furthermore, children with DCD do retain the ability to modify movement
coordination of preschool children was studied by Case-Smith (1996) to discover if increases in motor outcomes occur by implementing occupational therapy services. The results of the self-care scale showed that there was greater speed of rotation, greater grasp strength, pencil grasp, grasping scissors, and motor accuracy. The results of the PEDI Mobility Scale showed increased rotation speed, rotation drops, translation drops, pencil grasp, scissors grasp, and motor accuracy. The skills acquired through this intervention have clinical relevance since motor function did significantly improve, which can have a positive influence on function.

**Neuroplasticity**

In a randomized controlled trial, Klintsova et al. (2002) simulated alcohol exposure on rats that was comparable to prenatal alcohol exposure in the third trimester of humans. They measured the neuronal volume of the paramedian lobule (PML) in the cerebellum, had the rats perform an obstacle course for 20 days, and then measured the PML again. This measure was shown to have a significant increase in neuronal volume compared to the control group. Since the cerebellum, specifically the PML, helps with motor coordination, the study showed that neuroplasticity can occur secondary to repetitive motor training. Knowing that the cerebellum is also affected in children with FAS, this study showed that it was likely that neuroplasticity would also occur in these children after going through a motor training rehabilitation program. Moreover, a systematic review by Bayona and colleagues (2005) found that performing repetitive task-specific activities can cause cortical reorganization with long-lasting effects. A randomized clinical trial by van Vilet, et al. (2006) found that cortical reorganization occurs with task specific training. Neuroplasticity is best achieved with repeated practice.

**Conclusion**

It was shown in the literature that children with FAS have difficulty with fine motor coordination and slower reaction times. The clinical manifestations in children with FAS are analogous to those presented in children with DCD (Hillier, 2007; Jirikowic, et al., 2008). Neuromotor task training was proven to be a successful treatment approach to children with DCD, so it can be inferred that it would be an effective approach to treating children with FAS. However, there is no research on task-specific interventions targeting fine motor coordination in children with FAS. Using a reach and grasp program should help to increase the hand-eye coordination in children with FAS. Repetitive training and the concepts of neuroplasticity help to facilitate this learning (Hillier, 2007; Revie & Larkin, 1993). Physical therapists can use this information for clinical application when working with children with FAS.

More research needs to be conducted to discover the use of motor training in children with fetal alcohol syndrome. Randomized control studies should be performed to validate the conclusion. Follow-up studies on adults who received reaching and grasping interventions when they were children are also necessary, to determine if there are long-term benefits.

**Limitations**

There is limited evidence about the role of physical therapy with children diagnosed with FAS. Some of the reviewed research is of a lower level of evidence (3 and 4) which could decrease the reliability of this study. In addition, the majority of the evidence used for this study is greater than five years old, which may skew the findings.

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rats: II. A quantitative stereological study of synaptic plasticity in female 

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22(4), 384-391.

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alcohol spectrum disorders. BMC Pediatrics, 9, 35-43.

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