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Examining the Impact on Praxis for Children with Sensorimotor Deficits

Sara Elizabeth Durham
Eastern Kentucky University

EXAMINING THE IMPACT OF A MOVEMENT PROGRAM ON PRAXIS FOR CHILDREN WITH SENSORIMOTOR DEFICITS

By

Sara Elizabeth Durham

Thesis Approved:

Chair, Advisory Committee

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By

Sara Elizabeth Durham

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DEDICATION

This thesis is dedicated to my husband
and my parents for their support.

ACKNOWLEDGMENTS

I would first like to thank my thesis chair, Dr. Camille Skubik-Peplaski, for being willing to undertake this project with me and for guiding me, challenging me, and keeping me sane throughout the process. I would also like to thank the other committee members, Dr. Shirley O'Brien and Dr. Anne Fleischer, for their encouragement and feedback, especially their fresh eyes and ears when I needed help working through problems. Lastly, I would like to thank my husband, Isaac, and my parents, Bob and Michele, for their patience and unfailing encouragement.

ABSTRACT

The aim of this study was to discover how a movement program, utilizing principles of dance and sensory integration, effects motor and sensory outcomes for children with sensorimotor impairments. Participants' motor performance was assessed using the Bruininks-Oseretsky Test of Motor Proficiency prior to and following participation in the movement program. Additionally, sensory function was assessed using the Child Sensory Profile prior to participation, and sensory modulation was tracked throughout the program. This short-term, intensive program followed a protocol based on sensory integration principles and theories of motor learning. The analysis demonstrated the change in motor performance to be statistically significant, suggesting that the program was successful in improving praxis skills for the participants. These findings inform practice by supporting the use of an integrated movement program with children who have sensorimotor impairments. Although these preliminary findings show positive results, further research is needed.

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Introduction

The ability to accurately process and respond to sensory information, both from the body and the environment, greatly influences successful occupational engagement (Ahn, Miller, Milberger, & McIntosh, 2004; Ayres, 2005; Koenig & Rudney, 2010; Lane & Schaaf, 2010; Schaaf & Nightlinger, 2007). Difficulty processing sensory information is by no means a rare occurrence; Ahn, Miller, Milberger, and McIntosh (2004) found that, in their sample of kindergarten children, sensory processing issues arise in about 5-15% of typically developing children who do not have a diagnosed disability. Current evidence demonstrates that the occurrence of sensory processing deficits in children with various disabilities is anywhere between 40-88% (Ahn, Miller, Milberger, & McIntosh, 2004). Dr. A. J. Ayres, the first researcher to identify and investigate sensory processing problems, found that sensory processing and motor incoordination often go hand in hand, and both of these issues together contribute to deficits in occupational performance (Ayres, 1973; Ayres, 2005). Ayres' seminal work provided a strong foundation for occupational therapists to address concerns in sensory processing and motor incoordination and understand how both ultimately impact occupational performance.

Since sensory processing and motor incoordination issues arise so often, both in typically and non-typically developing children, occupational therapists can expect to see these problems in practice. This leads to a consideration of what approaches can be best utilized with a population of children experiencing sensorimotor deficits. A movement program that infuses dance concepts with principles of sensory integration provided opportunities for these children to regulate sensory input, progress toward motor outcomes, and experience a typical leisure occupation within a social context. This study examined the effects of this movement program on sensory and motor outcomes that impact occupational performance of children aged 5 to 8 years with sensorimotor deficits. The researchers hypothesized that children with sensorimotor deficits participating in a movement program will demonstrate an improvement in both sensory processing ability and motor coordination outcomes.

Defining Sensorimotor Deficits

In order to understand sensorimotor deficits, one must first understand sensory integrative dysfunction and sensory processing disorders. Ayres (1973) defines sensory integration as "the ability to organize sensory information for use" (p. 1). Therefore, a dysfunction in sensory integration would entail inadequate ability to organize sensory information, and thus an inability to use that information to interact effectively with the environment (Ayres, 1973). As sensory integration (SI) theory has been further researched and utilized in occupational therapy, the term sensory integration dysfunction, which Ayres used to describe the disorder as a whole, became increasingly confusing and problematic (Miller, Anzalone, Lane, Cermak, & Osten, 2007). For this reason, Miller et al (2007) proposed a diagnostic nosology with terms that described the various types of sensory integration dysfunction, all under the umbrella term of Sensory Processing Disorder (SPD).

The disorder consists of three major sub-classifications: sensory modulation disorder, sensory-based motor disorder, and sensory discrimination disorder (Biel, 2014; Miller et al, 2007). Sensory modulation disorder is further divided into three sub-types, including sensory over-responsivity, sensory under-responsivity, and sensory seeking.

Likewise, sensory-based motor disorder is also divided into sub-types: postural disorder and dyspraxia. Postural disorder refers to insufficient stabilization of the body during movement or at rest, while dyspraxia (sometimes referred to as developmental dyspraxia or developmental coordination disorder) refers to difficulties in initiating, planning, or executing a motor task (Miller et al, 2007). Finally, sensory discrimination disorder impairs the child's ability to distinguish between qualities of different sensory stimuli; these children will recognize the presence of a stimulus, but will be unable to explain its quality or locate it precisely. These sub-classifications of sensory processing disorder can occur simultaneously or separately from each other depending on the child (Miller et al, 2007).

Dyspraxia, one of the sub-classifications of Sensory Processing Disorder, is of particular interest to this study because it interferes with the child's ability to plan and execute skilled, novel motor tasks, like dance movements (Ayres, 1973). Ayres (1973) further describes dyspraxia (which she termed developmental apraxia) as the failure of the neurological process of integrating tactile, vestibular, and proprioceptive input resulting in an inability to plan movement to achieve novel tasks. Dyspraxia, although it is related to poor integration of sensory input, is perceived to be a motor output disorder because it often results in observable unskilled and uncoordinated movement. However, praxis actually occurs in the brain between receiving the sensory input and executing the motor output (Ayres, 1973). For this reason, Ayres (1973) proposes that improving the brain's ability to process sensory input will improve skills in praxis and thus improve the proficiency of motor output.

Difficulty processing sensory input and poor motor coordination and planning are intricately related (Ayres, 1973; Ayres, 2005). A child with sensory processing issues will often experience motor incoordination due to poor body scheme; likewise, a child with motor delays will present with sensory processing issues due to a lack of typical motor experiences (Ayres, 1973; Ayres, 2005; Buitendag & Aronstam, 2010). For this reason, children will often present with either sensory modulation or discrimination issues together with sensory-based motor difficulties (Buitendag & Aronstam, 2010; Miller at al, 2007). Sensorimotor deficits, then, is a term that refers to difficulties in both sensory and motor aspects of functioning. The term sensorimotor is not a diagnostic term, as are the sub-classifications of Sensory Processing Disorder discussed previously, but is a descriptive term used to conceptualize the difficulties with which these children present. Sensorimotor deficits best describe the struggles that the children included in this research study experience.

Performance Challenges for Children with Sensorimotor Deficits

Sensorimotor deficits create challenges in many areas of a child's daily functioning. Ayres (1973) used the term "adaptive response" to describe the ability to effectively utilize information from the environment to produce a goal-directed action. When this adaptive response is inhibited by inadequate sensory processing ability, children with sensorimotor deficits will struggle with motor components of tasks, especially when their sensory systems are overloaded (Ayres, 1973; Ayres, 2005; Biel, 2014; Magalhaes, Koomar, & Cermak, 1989). In addition to deficits in performance skills that will challenge participation, these children experience decreased occupational participation as a direct result of their specific sensory challenges (Koenig & Rudney, 2010). For example, a child that cannot regulate his or her response to auditory stimuli will struggle to participate in loud and stimulating environments; in fact, they may avoid these environments all together. These children's sensory challenges are by no means homogenous; the variety and complexity of these challenges make it difficult to define this population's performance deficits (Koenig & Rudney, 2010).

Dunn (1997) proposed that children's performance patterns can be predicted by considering four sensory responses: poor registration, sensitivity to stimuli, sensation seeking, and sensation avoiding. Even considering this model of performance patterns, there are many additional factors which can impact a child's performance, such as the intensity of their sensory responses, the rate and consistency of performance dysfunctions, and a child's capacity for task performance, which may vary from day to day (Dunn, 1997). The complexity and often unpredictability of these factors poses a challenge for understanding and predicting occupational performance deficits.

In a systematic review, Koenig and Rudney (2010) examined studies that provided evidence that children with sensorimotor deficits do, in fact, struggle with performance of daily occupations. The studies reviewed found deficits in every key area of occupation, including social and play participation, sleep, ADL and IADL, and education (Koenig & Rudney, 2010). Perhaps the most significant finding from this review was that occupational therapy intervention should promote social and community participation, because all areas of sensory processing challenges were moderately linked to challenges in social competence (Koenig & Rudney, 2010). This finding supports the use of a movement program as an intervention for these children because it not only addresses motor and sensory components of performance, but also addresses the social components within a group context.

Sensory Integration Therapy

Sensory integration (SI) therapy was developed by Dr. A. J. Ayres to address and remediate children's unusual behavioral responses to sensory stimuli and therefore promote successful occupational participation (Ayres, 1973; Ayres, 2005). SI intervention is based on several neurological assumptions presented by Ayres and supported by research (Ayres, 1973; Ayres, 2005; Lane & Schaaf, 2010; Preis & McKenna, 2014; Watling & Hauer, 2015). Of these neurological postulates, therapeutic intervention relies heavily on the concepts of neuronal plasticity and the brain's drive for integration (Ayres, 1973; Lane & Schaaf, 2010). Neuronal plasticity refers to the ability of the nervous system to adapt and change as a result of environmental demands (Lane & Schaaf, 2010). This neuronal plasticity supports SI intervention, which aims to directly change the nervous system's response to stimuli. Ayres also postulated that, based on principles of evolution and development, the brain seeks to organize itself into a coherent whole, a process she defines as integration (Ayres, 1973). She proposes that children who struggle to process sensory input have not reached this integration developmentally, and so intervention is needed to promote that process (Ayres, 1973). She explains that the objective of SI treatment "is progressive organization of the brain in a method as similar to the normal developmental process as is possible" (Ayres, 1973, p. 114). These neurological assumptions, along with others found in Ayres' research, provide the basis for SI intervention and attempt to explain why using it is effective for children with sensorimotor challenges.

In addition to these assumptions based on neuroscience evidence, SI treatment utilizes principles central to the creation of personalized intervention. Ayres (1973; 2005) has argued that active participation of the child and considerations of the specific child's needs are central to effective intervention. Schaaf and Miller (2005) present an overview of the key principles of SI intervention: 1) the just right challenge, 2) the adaptive response, 3) active engagement, and 4) child-directed treatment. These basic principles provide the foundation for therapeutic interventions, which provide multiple different kinds of stimulation designed to help children learn to process stimulation more regularly and produce an adaptive response.

There is potential for SI therapy to be helpful for many different populations, including Autism Spectrum Disorder (ASD), Fragile X syndrome, and Attention-Deficit Disorder (Schaaf & Miller, 2005). However, current evidence has been mixed and inconclusive and does not allow strong conclusions to be drawn as of yet about the efficacy of SI therapy (Lane & Schaaf, 2010; Cohn, 2001; Schaaf & Nightlinger, 2007). Despite the lack of evidence, SI is widely used (Lane & Schaaf, 2010; Schaaf & Nightlinger, 2007). To address this disparity, researchers have attempted to examine the evidence by looking at various elements of SI theory and intervention. Instead of measuring performance outcomes after SI treatment, Cohn (2001) decided to instead study the parent's perspectives of SI treatment. Her results demonstrated that parents perceived positive outcomes for their child when the SI therapy focused on three domains of their child's functioning: abilities, activities, and self-worth (Cohn, 2001). Parent's perspectives in this study were positive overall and demonstrated that SI, when it is family-centered, is perceived to be effective.

Lane and Schaaf (2010) decided to examine research in the field of neuroscience to see if current evidence supports the concept of neuroplasticity, which in turn would support sensory integration. The researchers found that the strongest available evidence that supports SI has been found in non-human subjects, and thus is problematic to apply to human subjects (Lane & Schaaf, 2010). However, the researchers did find that all the evidence, whether it was from a non-human or human sample, supported neuroplasticity and other assumptions of Ayres sensory integration theory (Lane & Schaaf, 2010). One of the most relevant findings of this review, after examining evidence from both human and non-human studies, was that "rich sensory input, contextualized in meaningful activity, facilitates neuroplasticity and thus growth, development, and behavior" (Lane & Schaaf, 2010, p. 387). Although research has been unable to demonstrate the efficacy of SI therapy using performance measures, other endeavors have been able to support the use of SI for various populations by using other measures, such as parent perspectives and neuroplasticity. In addition, other intervention approaches have not been demonstrated to be more effective than SI on the basis of performance outcomes (Polatajko & Cantin, 2010). Due to the current drive for evidence-based intervention approaches, research to further understand the usefulness of the SI approach with a focus on occupational performance measures is needed.

Using Dance as a Medium for Intervention

Dance is defined as the coordination of planned body movements to a rhythmic scheme, usually within the context of social interaction (Murcia, Kreutz, Clift, & Bongard, 2010). Related to this definition, dance has been found to positively contribute to physical, social, and emotional well-being, as perceived by the participants (Murcia, Kreutz, Clift, & Bongard, 2010). Although research has demonstrated the usefulness of dance in contributing to an individual's overall well-being, an understanding of the sensory and motor demands of dance is needed to demonstrate the usefulness of dance as a medium for providing sensory integration and praxis intervention.

As previously mentioned, children with sensorimotor deficits often struggle with motor control and praxis (Ayres, 1973; Miller et al, 2007). Dance has been found to inherently promote motor control as well as cognitive processes such as sequence learning and timing movement with appropriate speed, force, and duration (Bläsinga et al., 2012). The motor and postural control required to meet the demands of dance movement is significantly more than that of typical bipedal postures, which demands relatively little muscle contraction (Ayres, 1973; Bläsinga et al., 2012). Dance also requires postural biasing to prepare for movements, which is another aspect of motor control with which children with sensorimotor deficits may struggle (Bläsinga et al., 2012; Goodgold-Edwards & Cermak, 1990). Additionally, dance movement requires the dancer to rely on proprioceptive input to produce appropriate equilibrium reactions (Bläsinga et al., 2012). Dance provides significant challenges for postural control and equilibrium, both of which contribute to overall motor control.

Praxis, or the ability to initiate, plan, and execute a motor task, can also be addressed within the framework of a dance movement program (Miller et al, 2007). Since the ability to integrate sensory input for use is required for praxis, the sensory feedback given through the movements will improve praxis skills. Additionally, motor learning, which is used address praxis issues, is considered to progress in three stages: the cognitive phase, the associated phase, and the autonomous phase (Goodgold-Edwards &

Cermak, 1990). The cognitive phase is primarily under the control of the visual system, so this early motor learning requires visual cues to establish an ideation of the overall process of the movement (Goodgold-Edwards & Cermak, 1990). The associated phase is akin to a practice phase; during this stage of learning, proprioceptive feedback is vital to learning the demands of the movement on postural and muscular control (Goodgold-Edwards & Cermak, 1990). Lastly, the autonomous stage represents a state of preparedness and anticipation of environmental changes (Goodgold-Edwards & Cermak, 1990). In a similar way, dance movement is taught and naturally progresses through these phases, providing visual-perceptive cues, then practice with proprioceptive feedback, and finally the dancer is learning to generalize those movements through different environments, such as varying speed, force, duration of movement and transitioning between learned movements (Bläsinga et al., 2012).

In addition to addressing motor components of these children's deficits, dance can also be used to provide opportunities to integrate sensory stimuli. Ayres (1973) identified three sensory stimuli that can be therapeutically applied to organize the sensory system and improve the child's adaptive response: the tactile, proprioceptive, and vestibular senses. Ayres (1973) argues that these particular sensory modalities should be used in therapeutic intervention to promote adaptive responses and normalize sensory integration on a developmental progression. Tactile input in dance is often provided through the social demands of the occupation; the teacher corrects with tactile input and the dancers interact together through tactile input. The tactile sense will also be stimulated by the interaction between the dancer's body and the floor. Vestibular stimulation occurs naturally through the movement, as dance steps require the dancer to fight gravitational pull, accelerate and decelerate through space, and maintain control in rotary movement (Ayres, 1973; Bläsinga et al., 2012). Finally, the muscular contraction required during dance movement provides proprioceptive input, along with the impact of the feet on the ground when jumping, tapping, and leaping (Bläsinga et al., 2012).

Dance provides an opportunity to incorporate the tactile, vestibular, and proprioceptive senses into a purpose-driven and playful environment, which, in turn, is an important element of motor learning for development of praxis skills (Goodgold-Edwards & Cermak, 1990). Therefore, dance, by its very nature, provides ample opportunities to integrate sensory input and target motor control and praxis. The natural opportunities for sensory and motor experiences in dance movements can be further enhanced by supplementing techniques used in sensory integration therapy. Ayres explains that intervention "seeks responses that reflect better sensory integration and more normal patterns of sensory input as opposed to improved motor skill for the sake of skill itself" (Ayres, 1973, p. 115). Reflecting this reason, using dance as a medium for sensory integration does not necessitate that the children who participate will acquire dance skills as an outcome, although it might happen secondarily. Instead, the aim of the movement program is to utilize dance, as a valued leisure occupation, to impact the children's sensory and motor function, with the result of improving their performance in everyday occupations.

Research in the Field of Dance Movement Therapy

Although this study does not utilize dance movement therapy (DMT), research in the field nevertheless provides support for the use of dance as a therapeutic approach. DMT, like music or art therapy, is a branch of alternative therapies that centers on the theory that expressing oneself through music-driven movement is inherently therapeutic (Chaiklin & Wengrower, 2009). Zilius (2010) wrote an article with the intent of reviewing DMT and its application for different pediatric conditions. The author found that a limited number of randomized controlled trials have demonstrated the effectiveness of DMT with pediatric conditions such as attention deficit hyperactivity disorder (ADHD), autism, and pervasive developmental disorders (Zilius, 2010). Children diagnosed with ADHD and autism, as has been previously mentioned, often are also experiencing varying degrees of sensory processing disorder. The author argues that, although scientific evidence might be minimal at this point in the profession's history, DMT is a recognized treatment that should be further researched and better understood by practitioners so that more individuals could benefit from this enriching, holistic treatment (Zilius, 2010).

Barteneiff (1971), in a seminal work addressing the usefulness of DMT, explained that it is typically used to address behavioral or emotional issues, but that it can also be used to address motor deficits. In one recent example, Clark (2011) advocates for the combination of dance/movement therapy techniques with physical therapy for children with Down syndrome. Dance has been shown to improve deficits in balance, motor skills, and muscle tone in children (Barteneiff, 1971; Clark, 2011). The author explained that physical therapy, which is typically used to address these deficits for children with Down syndrome, can become tedious and redundant for these children which reduces exercise compliance. For this reason, Clark (2011) proposed that physical therapy exercises be transferred into a dance program to promote engagement and participation for these children. There is no current evidence that addresses the use of DMT with sensorimotor deficits, so this evidence can only be tentatively applied when considering its transferability to this population. However, the fact that dance is used therapeutically to address both physical and behavioral issues in varying populations provides support for considering its use with children with sensorimotor deficits.

Chapter Two: Article Manuscript

Introduction

The ability to accurately process and respond to sensory information, both from the body and the environment, greatly influences successful occupational engagement (Ahn, Miller, Milberger, & McIntosh, 2004; Ayres, 2005; Koenig & Rudney, 2010; Lane & Schaaf, 2010; Schaaf & Nightlinger, 2007). Difficulty processing sensory information is by no means a rare occurrence; Ahn, Miller, Milberger, and McIntosh (2004) found that, in their sample of kindergarten children, sensory processing issues arise in about 5-15% of typically developing children who do not have a diagnosed disability. Current evidence demonstrates that the occurrence of sensory processing deficits in children with various disabilities is anywhere between 40-88% (Ahn, Miller, Milberger, & McIntosh, 2004). Dr. A. J. Ayres, the first researcher to identify and investigate sensory processing problems, found that sensory processing and motor incoordination often go hand in hand, and both of these issues together contribute to deficits in occupational performance (Ayres, 1973; Ayres, 2005). Ayres' seminal work provided a strong foundation for occupational therapists to address concerns in sensory processing and motor incoordination and understand how both ultimately impact occupational performance.

Since sensory processing and motor incoordination issues arise so often, both in typically and non-typically developing children, occupational therapists can expect to see these problems in practice. This leads to a consideration of what approaches can be best utilized with a population of children experiencing sensorimotor deficits. A movement program that infuses dance concepts with principles of sensory integration provided opportunities for these children to regulate sensory input, progress toward motor outcomes, and experience a typical leisure occupation within a social context. This study examined the effects of this movement program on sensory and motor outcomes that impact occupational performance of children aged 5 to 8 years with sensorimotor deficits. The researchers hypothesized that children with sensorimotor deficits participating in a movement program will demonstrate an improvement in both sensory processing ability and motor coordination outcomes.

Literature Review

Performance Challenges for Children with Sensorimotor Deficits

In order to understand the performance challenges associated with sensorimotor deficits, one must first understand sensory integrative dysfunction. Ayres (1973) defines sensory integration as “the ability to organize sensory information for use” (p. 1). Therefore, a dysfunction in sensory integration would entail inadequate ability to organize sensory information, and thus an inability to use that information to interact effectively with the environment (Ayres, 1973). Difficulty processing sensory input and poor motor coordination and planning are intricately related (Ayres, 2005). A child with sensory processing issues will often experience motor incoordination due to poor body scheme; likewise, a child with motor delays will present with sensory processing issues due to a lack of typical motor experiences (Ayres, 2005; Buitendag & Aronstam, 2010). Sensorimotor deficits, then, is a term that refers to difficulties in both sensory and motor aspects of functioning.

Dyspraxia is of particular interest to this study because it interferes with the child’s ability to plan and execute skilled, novel motor tasks, like dance movements (Ayres, 1973). Ayres (1973) further describes dyspraxia (which she termed developmental apraxia) as the failure of the neurological process of integrating tactile, vestibular, and proprioceptive input resulting in an inability to plan movement to achieve novel tasks. Dyspraxia, although it is related to poor integration of sensory input, is perceived to be a motor output disorder because it often results in observable unskilled and uncoordinated movement. However, praxis actually occurs in the brain between receiving the sensory input and executing the motor output (Ayres, 1973). For this reason, Ayres (1973) proposes that improving the brain's ability to process sensory input will improve skills in praxis and thus improve the proficiency of motor output. Sensorimotor deficits create challenges in many areas of a child's daily functioning. Ayres (1973) used the term "adaptive response" to describe the ability to effectively utilize information from the environment to produce a goal-directed action. When this adaptive response is inhibited by inadequate sensory processing ability, children with sensorimotor deficits will struggle with motor components of tasks, especially when their sensory systems are overloaded (Ayres, 1973; Ayres, 2005; Biel, 2014; Magalhaes, Koomar, & Cermak, 1989). These children's sensory challenges are by no means homogenous; the variety and complexity of these challenges make it difficult to define this population's performance deficits (Koenig & Rudney, 2010).

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Praxis, or the ability to initiate, plan, and execute a motor task, can also be addressed within the framework of a dance movement program (Miller et al, 2007). Since the ability to integrate sensory input for use is required for praxis, the sensory feedback given through the movements will improve praxis skills. Motor learning to address praxis issues is considered to progress in three stages: the cognitive phase, the associated phase, and the autonomous phase (Goodgold-Edwards & Cermak, 1990). The cognitive phase is primarily under the control of the visual system, so this early motor learning requires visual cues to establish an ideation of the overall process of the movement (Goodgold-Edwards & Cermak, 1990). The associated phase is akin to a practice phase; during this stage of learning, proprioceptive feedback is vital to learning the demands of the movement on postural and muscular control (Goodgold-Edwards & Cermak, 1990). Lastly, the autonomous stage represents a state of preparedness and anticipation of environmental changes (Goodgold-Edwards & Cermak, 1990). In a similar way, dance movement is taught and naturally progresses through these phases, providing visual-perceptive cues, then practice with proprioceptive feedback, and finally the dancer is learning to generalize those movements through different environments, such as varying speed, force, duration of movement and transitioning between learned movements (Bläsinga et al., 2012).

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Dance provides an opportunity to incorporate the tactile, vestibular, and proprioceptive senses into a purpose-driven and playful environment, which, in turn, is an important element of motor learning for development of praxis skills (Goodgold-Edwards & Cermak, 1990). Therefore, dance, by its very nature, provides ample opportunities to integrate sensory input and target motor control and praxis. The natural opportunities for sensory and motor experiences in dance movements can be further enhanced by supplementing techniques used in sensory integration therapy. Ayres explains that intervention "seeks responses that reflect better sensory integration and more normal patterns of sensory input as opposed to improved motor skill for the sake of skill itself" (Ayres, 1973, p. 115). Reflecting this reason, using dance as a medium for sensory integration does not necessitate that the children who participate will acquire dance skills as an outcome, although it might happen secondarily. Instead, the aim of the movement program is to utilize dance, as a valued leisure occupation, to impact the children's sensory and motor function, with the result of improving their performance in everyday occupations.

Methods

Utilizing a quasi-experimental, one group pretest posttest design, this study examined the effect of a movement program on sensory and motor outcomes for children with sensorimotor impairments. Outcome measures used to determine if any change occurred in sensory and motor aspects of performance included the Child Sensory Profile 2 (CSP2) and the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2). Pre-testing was completed one week prior to the intervention and post-testing was completed one week following the intervention. The movement program was provided in 8 one-hour sessions, twice a week for 4 weeks.

Participants

A convenience sample of participants was recruited using recruitment flyers at an outpatient pediatric therapy clinic in the southeast region of the United States. The inclusion criteria for the study included that participants be between the ages of four and ten years old with sensorimotor deficits as determined by a clinical diagnosis and have the ability to follow directions. Participants were excluded from the study if they had any intellectual or neurological disabilities. Participation in the study was free, and provided no monetary reward to the participants. Institutional Review Board approval was obtained prior to initiation of the study. Parents of the participants signed an informed consent document and the participants signed a child assent form before data collection.

Outcome Measures

Child Sensory Profile 2

Prior to intervention, the Child Sensory Profile 2 (CSP2) was completed for each child; this measure was not completed following intervention, as it was used only to characterize the participants' sensory processing abilities and challenges to better target intervention. The CSP2 is a parent-report questionnaire designed to detect the influence of possible sensory processing deficits on occupational performance (Dunn, 2014; Ohl et al, 2012). The assessment captures the child's sensory processing abilities in six areas: auditory, visual, touch, movement, body position, and oral processing. Additionally, the CSP2 considers the child's capabilities in three behavioral areas, including conduct, social emotional responses, and attentional responses associated with sensory processing. The child's scores on the CSP2 places the child on a normal curve, comparing their abilities to that of their peers. The scores also determine whether the child is sensory seeking or avoiding, and the degree to which they detect and register sensory input.

The CSP2 has been found to have good to excellent test-retest reliability over time, and the interrater reliability was found to be mostly acceptable to good (Dunn, 2014). Of particular relevance to this study, during reliability and validity testing of the CSP2, it was discovered that younger children (ages three to eight years old) scored higher on sensory seeking items that the older cohort, and this difference is considered statistically and clinically significant (Dunn, 2014). Although the reason for this difference has not been researched, it is likely a result of developmental changes; as younger children are learning and developing, it is assumed that they would seek more experiences as a whole (Dunn, 2014). For this study, since the participants fall under the younger children's age range, scores on sensory seeking items should be considered carefully.

Bruininks-Oseretsky Test of Motor Proficiency

The Bruininks-Oseretsky Test of Motor Proficiency, 2^{nd} Edition (BOT-2) is a norm-referenced assessment of both fine and gross motor skills. The BOT-2 examines the child's performance on fine manual control, manual coordination, body coordination, and strength and agility items. For the purpose of this study, the Short Form, which provides scores for select items under each subtest, was used. Test-retest and interrater reliability and validity scores were all found to be high to extremely high (Bruininks & Bruininks, 2005). Pre and post test scores on the BOT-2 were analyzed to determine if participation in the movement program had any effect on motor performance, which in turn impacts occupational performance.

Data Collection Sheets

Each participant was paired with an individual occupational therapy student researcher who assisted with data collection and implementation of the movement program. Following each session, the student researchers filled out data collection sheets regarding the participants' performance. The sheets included information about the number of physical and verbal cues the participant required during the session, as well as the participant's regulation. The frequency and type of cues needed were analyzed to determine trends in sensory processing and praxis skills within the context of the movement program.

Procedure

Movement Program

Following pretesting, the participants engaged in a structured movement program that combined elements of social dance, line dance, tap, ballet, and other dance forms with the concepts of sensory integration therapy and praxis. The co-primary researchers developed the movement session protocol and directed the program. Each one-hour session consisted of a warm-up that incorporated vestibular stimulation to organize the participants' sensory systems and stretches to promote integration of primitive reflexes (Ayres, 1973; Berne, 2006). After the warm-up, participants engaged in planned movement patterns that challenged integration of tactile, vestibular, and proprioceptive sensory input. The movement patterns also challenged the participants' praxis abilities by targeting ideation, motor planning, and execution elements of praxis (Goodgold-Edwards & Cermak, 1990; Miller, 2007). These elements were targeted progressively over the course of the sessions so that by the end of the program the movement challenges had increased from only requiring execution to requiring all three elements. In addition to the program utilized within the sessions, home exercise programs (HEP) were employed to encourage practice of learned motor skills at home. The HEPs included videos demonstrating learned movements in rhythm to either a metronome or a familiar song from the previous sessions.

Alert Program

During the movement program, each participant's student researcher ensured that the planned movements were graded at the correct level for the individual child to promote optimal occupational performance. Additionally, the student researchers implemented the Alert Program with the participants as necessary to support the child's sensory system. The Alert Program (AP) was developed by Williams and Shellenberger (1996) to teach children to understand their level of arousal as well as to develop self-regulation skills to promote occupational engagement. In the AP program, children learn to describe their arousal state as "engine speeds" and then learn about strategies (called "engine changers") that can modify their arousal state if needed. If a child recognizes their engine is running too fast or too slow, they will then utilize strategies to slow their engine down or speed it up to reach the optimal speed. During the movement sessions, the participants were taught to use the Alert Program and the student researchers helped each child check their arousal states throughout each session and provided engine changers as needed to promote each child's optimal arousal state for engagement in the movement program.

Data Analysis

Outcome measures were analyzed using the Minitab statistical software (Minitab, Inc.). The mean change scores for both the BOT-2 and the data collection sheets were compared using paired t-tests. For both outcome measures, a p-value of <.05 was considered statistically significant. Additionally, each of the subtests of the BOT-2 were analyzed separately, and the Bonferroni adjustment was used to counteract the likelihood of a multiple comparisons error (Domholdt, 2005). The Bonferroni adjustment requires that the confidence level be divided by the number of comparisons being made. Therefore, for the analysis of the eight subtests of the BOT-2, a p-value of <.00625 was considered statistically significant.

Results

A total of six participants were recruited for the study; four females and two males. The age of the participants ranged from five to eight years old. Each participant was receiving therapy services at an outpatient therapy clinic. Table 1 represents the demographic information for each participant. Pseudonyms were assigned for all participants.

Table 1: Demographic Representation of Participants

Participant	**Age**	**Gender**
Abigail	5 years, 6 months	Female
Amelia	6 years, 10 months	Female
Cory	8 years, 4 months	Male
Evan	5 years, 5 months	Male
Jackie	6 years, 11 months	Female
Kaylee	8 years, 0 months	Female

Sensory Profile

The Sensory Profile was utilized to understand sensory patterns and behavior of each participant. Kaylee demonstrated significant sensory seeking behaviors, especially in areas of movement and body position. However, she also demonstrated fairly significant sensory sensitivity, especially concerning visual, tactile, and oral input. In some areas she seeks input, and in other areas she shies away from input, depending on her ability to process that particular sensation and generate an adaptive response. Her sensory processing responses resulted in significant difficulties in areas of social emotional behavior, including low self-esteem, sensitivity to criticism, and feelings of failure. Similar to Kaylee's Sensory Profile, Jackie's scores revealed processing patterns that varied for different types of input. She is sensitive to tactile and auditory input, but is under-responsive to visual and body positioning input. Her profile also indicated significant social emotional difficulties similar to Kaylee's, as well as attentional concerns, such as staring intensively at people and objects and being easily distracted.

Evan demonstrated both sensory seeking and avoiding behaviors as well; however, his responsivity to every type of stimuli was only slightly out of the range of normal. He seeks tactile, movement, and oral sensory input, and avoids auditory and visual input. In terms of behavioral responses, he has attentional concerns related to staying on task. Cory is significantly under-responsive to input, especially regarding body position. Although he misses many forms of input, he is also specifically sensitive to auditory and tactile input. His behavioral responses to sensory processing all fell within normal limits or just slightly outside of that range, with social emotional responses being the most significant. He does not easily accept criticism, and struggles with fears and strong emotional outbursts.

Much like Cory, Amelia is under-responsive to sensory input to a significant degree, especially visual, tactile, movement, and oral sensory input. Amelia also had the most significant behavioral responses; she struggles with conduct, social emotional, and attentional behaviors related to her sensory processing behaviors. Lastly, Abigail's scores on the Sensory Profile were significantly different from the rest of the participants. All her scores were within normal limits except for her ability to process body positioning.

She tires easily and frequently; she will prop herself on objects or people to remain upright.

Bruininks-Oseretsky Test of Motor Proficiency

The BOT-2 yields two composite scores: the total point score and the standard score. The total point score is a composite score of all raw scores within each subtest, and the standard score is derived from the total point score when compared to the normative sample. The results of the paired t-test ran on both the total point score mean difference and the standard score mean difference yielded statistically significant results. Using a 95% confidence interval, the total point score mean difference was between .21 and 11.13 (p-value 0.044). Similarly, the total standard score mean difference was found to be between .92 and 11.41 (p-value 0.029). As demonstrated in Figure 1, all but one participant made improvements on the BOT standard score following the movement program.

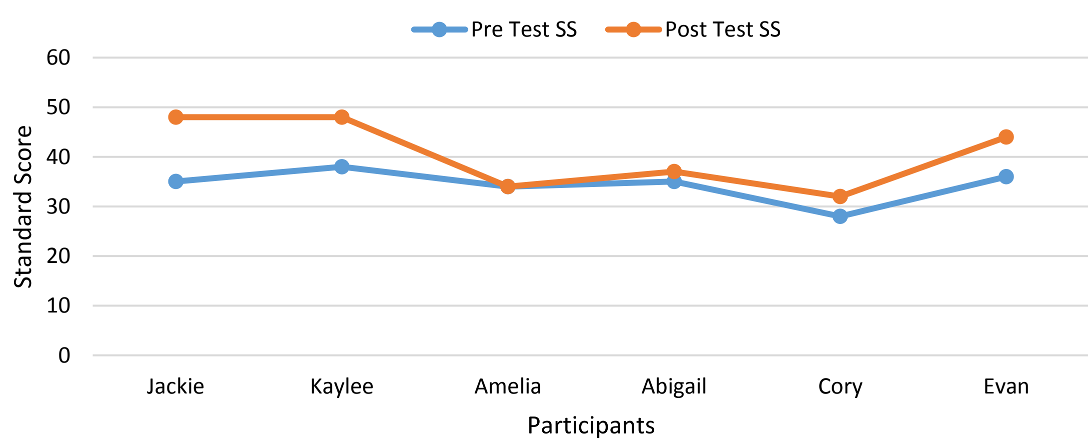

Figure 1: Change in Standard Scores on BOT

After finding a significant mean difference in both the total scores and the standard scores, a paired t-test was run to analyze the mean difference between pre and post scores of each of the eight subtests (Table 2). None of the subtests resulted in a statistically significant difference using the Bonferroni error adjustment (p-value 0.00625). However, the mean difference in the strength subtest did have a p-value of 0.045; with an unadjusted error rate of 5% (p-value 0.05), the mean difference in the strength subtest was between .053 and 2.947.

Table 2: Results of Paired T-Test on BOT Subtests

BOT Subtests	**Mean Pre-Test**	**Mean Post-test**	**p-value**
Fine Motor Precision	6.50	7.17	0.286
Fine Motor Integration	6.00	6.50	0.296
Manual Dexterity	3.33	4.67	0.191
Bilateral Coordination	5.83	6.00	0.822
Balance	5.67	6.33	0.501
Running Speed/Agility	3.33	4.00	0.603
Upper-Limb Coordination	5.17	5.17	1.000
Strength	2.67	4.17	0.045

Data Collection Sheets

The frequency of physical and verbal cues recorded in the data sheets in the first and last sessions were analyzed to find a mean difference using paired t-tests. There was no statistically significant change in verbal cues from the first to last session. The mean change for verbal cues was 4.67, with a range from -3 to 12. However, there was a significant change in physical cues. The mean difference in physical cues was between 4.76 and 10.90 (p-value 0.001). Since the mean difference was significant, the physical cues were analyzed to look for trends across time. Figure 2 illustrates the number of physical cues each participant received across the eight sessions. Although the number of cues fluctuated across the sessions, the trend runs down overall. When individual participants' physical cues are plotted, the trend line runs down for each participant, but to varying degrees, as illustrated in Figure 3.

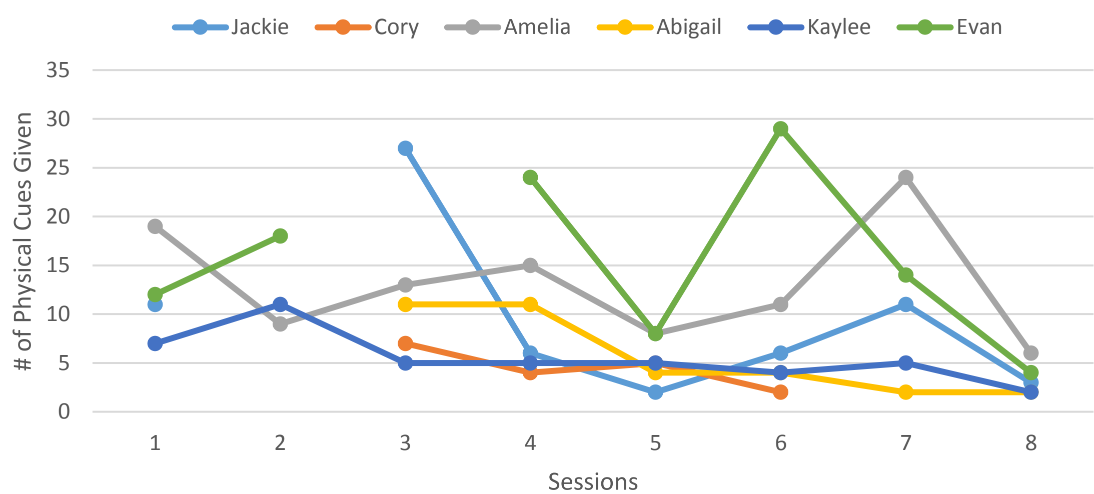

Figure 2: Physical Cues across Sessions

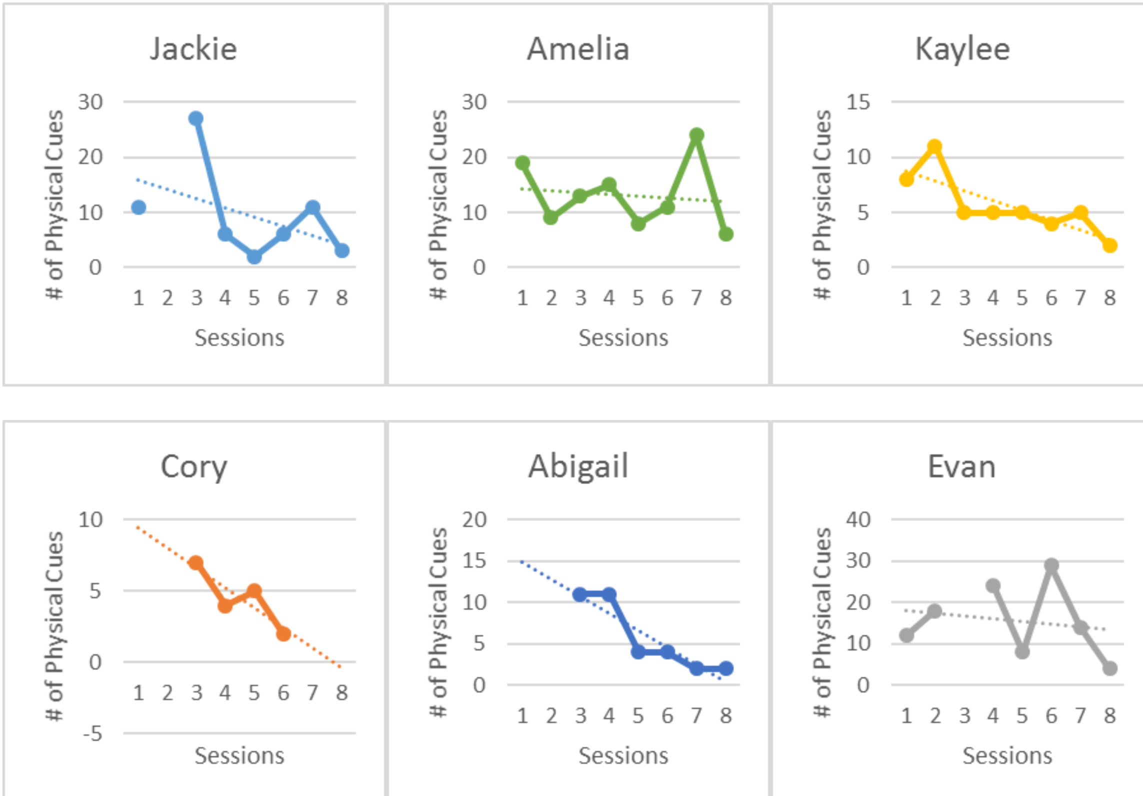

Figure 3: Physical Cues Across Sessions by Participant

Discussion

Children with sensorimotor deficits often struggle with novel motor tasks, related to deficits in praxis (Ayres, 1973; Goodgold-Edwards & Cermak, 1990). The movement demands of this program required each participant to engage in patterns that weren't familiar, which required ideation, motor planning, and execution skills. To increase successful participation, the program was designed to target aspects of praxis sequentially. The first three sessions focused on execution of movement patterns, with visual models and both verbal and physical cues to decrease the need for ideation and motor planning. The next two sessions targeted motor planning by requiring the participants to take learned movement patterns and apply them in new ways. The last two sessions focused on ideation, and the participants were asked to design their own movement patterns based on learned patterns. The design of this program was ideal for this population of children because it purposefully taught movement patterns in a way that promoted their success. Their successful participation resulted in notable improvement in their motor skills, both within the context of the movement sessions but also overall as evidenced by their improvement on the BOT-2.

Despite the relative short intervention period (8 sessions), all but one participant made substantial improvement on the BOT-2. When each subtest was examined, the only statistically significant change across all participants was the strength outcome; although individual participants improved in varying areas, no other subtest demonstrated significant changes across all participants. The change in strength was likely a result of the children's increased participation. This improved strength was not a surprise, since increased participation in any form of physical exercise is known to increase strength. However, an increase in strength for this population is significant because it suggests that the movement program was able to promote successful participation for each child, despite their deficits in praxis and motor control.

Although the results of the Sensory Profile were unique to each child, each participant demonstrated more avoiding behaviors than their peers, with only one participant falling within one standard deviation from the mean, two participants within one and two standard deviations, and three participants more than two standard deviations from the mean. Avoiding sensory input results in a lack of movement experiences, which, in turn, impacts the strength of the child (Ayres, 2005). Additionally, the participants' scores on the Sensory Profile indicated difficulties processing sensory input from either or both of the movement and body position sections. These sensory regulation concerns are directly related to motor proficiency (Ayres, 1973: Ayres, 2005). The movement program utilized strategies through the Alert Program to help the children integrate sensory input from their own bodies and their bodies' movement, which promoted their successful participation. Additionally, the program was designed to target praxis skills sequentially to provide the opportunity to participate successfully in movement. Therefore, the design of the program successfully promoted participation, which resulted in an increased overall motor control and strength.

In addition to the change in motor scores on the BOT-2 assessment, the children also demonstrated a significant decrease in their need for physical cues during the movement sessions. The number of physical cues decreased significantly from the first to eighth sessions. However, the eighth session was a "recital", which encompassed the performance of learned movement patterns to a familiar song in front of an audience consisting of their families. The children had practiced these movement patterns from the very first session, and so it made sense that they needed fewer physical cues during this session, since nothing new was introduced. When the same statistical analysis was run comparing the first and seventh sessions, during which some new movement patterns were introduced, there was no significant mean difference. Due to this, it was difficult to tell from the analysis if the children's need for physical cues for movement patterns was decreased overall, or if their need for physical cues with only familiar movement patterns was decreased. Nevertheless, the fact that they required fewer physical cues supports the idea that the participants were able to demonstrate improvement in those movement patterns, even after only eight sessions.

However, when the participants' need for cuing was examined individually, a downward trend was noticed across the sessions. For some, this change was more significant than others. This could be due to a variety of factors related to the structure of the program, including the verbal and visual cues provided by the instructors when learning new movement patterns and continued repetition of new patterns in different contexts. Additionally, the physical and verbal cues were provided by the student researcher paired with each participant, and the number of cues provided may have changed across the sessions as the student researchers better understood their child's needs and learned how to promote their success while also challenging them. Regardless, the decrease in physical cues points to improved success in performing familiar movement patterns.

While the change in physical cues was significant, there was no statistical change in the number of verbal cues provided to the participants. The change in verbal cues varied greatly across the participants, although all but two participants required less verbal cues in the last session. One potential explanation for this was that the children were given verbal cues rather than physical cues to utilize the Alert Program as well as to attend to the task at hand. These demands remained constant throughout the sessions, as consistent "engine checks" were run and each child continued to need verbal cues to attend. Whereas the physical cues were given to assist in the execution of motor tasks, of which the children needed less as a result of their experience with repetitive movement patterns, the verbal cues to check arousal level and attend to task continued to be required.

Implications for Practice and Further Research

The results of this study illustrate the utility of designing a movement program combining elements of dance with sensory integration and praxis intervention, and thus imply the following for occupational therapy practice and research:

- A movement program can be used to significantly improve motor coordination and strength for children with sensorimotor deficits.
- The movement program was shown to be effective after a relatively short but intensive time period (twice per week for four weeks).
- Designing the program for successful participation is important to reach desired outcomes.
- Repetition of novel movement patterns results in improved praxis ability related to those movement patterns and improved confidence in executing these movements (as observed in the performance of these movements for the families at the conclusion of the study).
- Further research is needed to examine the long term effects of participation in a movement program, to determine if significant improvements would occur in other outcomes following a longer intervention period, and to discover if the program could be utilized with other populations.
- Use of the Sensory Integration and Praxis Test (SIPT) should be considered to further validate changes in motor planning abilities of the participants.

Limitations

The small sample size, although appropriate for the purpose of substantiating the need for further research, is a significant limitation of the study that impacts generalizability of the results. Also related to the sample, the participants were a convenience sample and were representative of a heterogeneous population, which further impedes the generalizability of the results. In addition to the already diverse population considered to have sensorimotor deficits, one participant was discovered to have both Attention Deficit Hyperactivity disorder and Autism Spectrum disorder once the study had already begun. Although this participant did have sensorimotor deficits, the child's additional deficits may have skewed the study's overall results.

In addition to limitations related to the sample, the intervention period (4 weeks) was relatively short, which may not have been long enough to see all potential outcomes. However, an intensive program (2 hours per week) was chosen to maximize intervention during that short period. Another limitation of the study pertains to the conduction of the pre and post testing. Each student researcher conducted all the pre and post-tests with the participant they were paired with throughout the study. This was done to ensure reliability of the results for the individual participants. However, for one participant, due to a scheduling conflict, the pre-test was given by a different student researcher. Although the outcome measures used were standardized, results are more consistent when administered by the same examiner. Another potential limitation of the testing overall is that higher results on the post-test may be, in part, related to the participants' familiarity with the examiner and the demands of the test. However, this is a concern inherent in any study that utilizes a post-test format.

Another limitation of the study was the use of the data collection sheets, which were filled out by the student researchers upon reflection after each session. To promote rigor, video recordings of the movement sessions were available to aid in the reflection process and the student researchers completed self-reflection and documentation related to each session to increase rigor. Although the data collection sheets cannot be considered a complete and accurate picture of the events of the sessions because they were completed retrospectively, therapy notes, which are used in practice for data collection and tracking progress, are also completed retrospectively.

Conclusion

The results of this study provide preliminary support to the use of a movement program for children with sensorimotor deficits to improve praxis and motor coordination. Significant improvements in overall motor coordination and strength were noted across all participants, as well as increased competence in learned movement patterns, as indicated by a decline in the need for physical cues. Elements of the program design which promoted successful participation, such as sequential targeting of praxis skills and support for sensory integration, were discussed in relation to their contribution to the participants improved motor control and strength.

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