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Locomotor Skill Development in Response to an Electronic Visual Exercise System in Children with Sensory Impairments

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LOCOMOTOR SKILL DEVELOPMENT IN RESPONSE TO AN ELECTROINIC VISUAL EXERCISE SYSTEM
IN CHILDREN WITH SENSORY IMPAIRMENTS

BY

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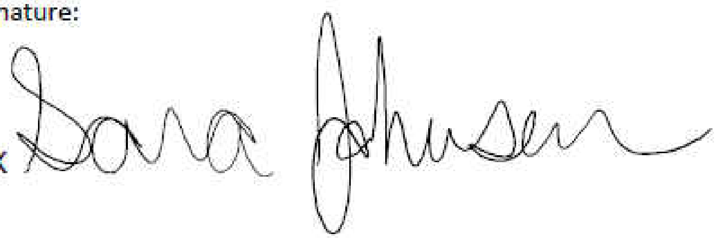
x 

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ABSTRACT

Children with sensory impairments associated with a physical or intellectual disability often have delay in fundamental motor skill development. The dual purpose of this study was to observe locomotor skill development, in response to an electronic visual exercise system, as well as interrater reliability of the assessment method. Eight children between the ages of seven and fourteen were recruited from an adapted physical education program. Pre-and post-test analysis of data collected via the Test of Gross Motor Development – Second Edition revealed no significant changes in motor skill development. Interrater reliability statistical analysis revealed a strong ICC value, suggesting excellent interrater reliability of the Test of Gross Motor Development-Second Edition.

Table of Contents

List of Tables

CHAPTER I

INTRODUCTION

In 2011, it was reported that in the United States, between 5% and 16% of all preschool-aged children were diagnosed with a sensory processing disorder (James et al, 2011). A sensory processing disorder is defined as any limitation in the perception or organization of sensory input within the central nervous system. Children who have been diagnosed with an intellectual or physical disability often have associated and varied sensory impairments (Newschaffer et al, 2007).

Disabilities, such as autism spectrum disorder, pervasive developmental disorders – not otherwise specified, and Down Syndrome, are among the most commonly diagnosed intellectual disabilities (Newschaffer et al, 2007). Autism spectrum disorder has a prevalence of 1 in every 68 children, aged 8 and younger (Montigney et al, 2017). Although the exact etiology behind autism spectrum disorder is unknown, possible linkage to certain pre-and post-natal conditions have been suggested (Berry et al, 2013). Often seen in children with autism spectrum disorder are sensory impairments such as poor balance and coordination, hypersensitivity to auditory or visual stimuli, and inability to perceive body language and social cues (Newschaffer et al, 2007). Comparable to autism spectrum disorder, the etiology of pervasive developmental disorders – not otherwise specified (PDD-NOS) is unknown but research suggests a possible link to certain pre-and-post-natal conditions such as infection, low birth weight, premature birth, and poor maternal diet. (Berry et al, 2013). Research has observed that PDD-NOS is diagnosed in approximately 15 out of every 10,000 children (Fombonne, 2003). Much like autism spectrum disorder, those diagnosed with PPD-NOS have been identified as having sensory impairments. Sensory impairments found in these individuals could include hypersensitivity to auditory or visual stimuli or difficulty processing emotional reactions (Walker et al, 2004).

One intellectual disability that does have a true etiology is Down Syndrome. Down Syndrome is a chromosomal abnormality, and is the most common chromosomal abnormality among children, occurring in 1 out of every 1000 live births (Nadkarni et al, 2012). Much like autism spectrum disorder and PPD-NOS, Down Syndrome is associated with sensory impairments, such as but not limited to hyper-mobility of the joints, visual impairments, and difficulties in auditory processing (Savelsbergh, 2000). It should be recognized that all the aforementioned intellectual disabilities are also associated with significant motor function impairment.

Much like intellectual disabilities, various physical disabilities are associated with sensory impairments. Both cerebral palsy and traumatic brain injuries have been shown to alter brain function, and ultimately impair sensory processing function. Cerebral palsy and traumatic brain injuries are both caused by injury or damage to brain tissue. Events such as motor accidents, falls, blood flow restriction, or oxygen deprivation are all linked to brain tissue damage. Brain tissue damage is evaluated by medical imaging and neurological testing (Faul, 2010). Cerebral palsy has been estimated as the most common cause of chronic physical disability in children (Oskoui et al, 2013). In contrast, adolescents between ages 15 – 19, and adults over 65 years are the most likely to sustain a traumatic brain injury (Faul, 2010). Although primary demographics for these two physical disabilities are different, both are associated with similar sensory impairments. Hypersensitivity to temperature, limited proprioception, or impairment in audio or visual processing (Ostensjo, 2004).

Compared to typically developed children, children with disabilities have higher reports of underdeveloped fundamental motor skills (Leonard & Hill, 2014). The underdevelopment of motor skills can predispose a child for social exclusion, academic failure, and poor overall heath (Macdonald et al, 2017). Burns et al completed a study that observed the relationship of motor skill development in children with disabilities and overall academic achievement (Burns et al, 2004). This study provided support for the theory that motor skill development is linked to academic success.

Much like academic success, social inclusion has been suggested to have a direct correlation to motor skill development in children with disabilities. A study conducted in 2001 observed the level of inclusion typically developed students displayed towards their atypically developed peers, while in a physical education class (Place & Hodge, 2001). Results of this study found that as proper motor skill execution was demonstrated by the atypically developed students, the typically developed students were more inclined to include the atypically developed children in social groups and class-time activities. This is just one example of literature that supports the theory that improved motor skill development can increase social inclusion among atypically developed children.

In 2000, it was reported that people with intellectual and physical disabilities are more likely to lead an unhealthy lifestyle and be overweight or obese, compared to the general population (Gravestock, 2000). To decrease the risk of developing an unhealthy lifestyle, motor skill development and physical activity need to be implemented in individuals with disabilities. The topic of motor skill development in relation to health status in those with disabilities has gained attention from researchers over the past several years. Just this year, a study was published that evaluated the health-related quality of life in children with disabilities that limited motor function. Using parent/caregiver self-report methods, data regarding participant's overall quality of life was gathered. Results of this study suggest as motor skill function decreases, so does quality of life (Bray et al, 2017). Chen et al (2011) and Canty-Mitchell et al (2005), have also completed similar studies observing the quality of life in children with motor function impairments. All three studies produced results suggesting a strong correlation between motor function and health status.

A commonly used tool, the Test of Gross Motor Development – fifth edition, has been utilized for motor skill assessment of children with disabilities since it's development in 2000 (Ulrich, 2000). Since its development, the assessment has since been revised, and is now on its second edition. This assessment tool is broken down into two subtests – locomotor skills and object control skills. The use of the TGMD-2 to evaluate motor skills in children, is widely represented in literature (Houwen et al, 2010, Portney & Watkins, 1993, Parkkinen & Rintala, 2004, and Simons et al., 2008).

Compared to a century ago, wireless technology is becoming more evident in everyday life. Some educators argue that it has become a critical platform in delivering an effective and comprehensive education to students of all ages and abilities (McDonald & Wegis, 2016). Although the use of technology in physical education settings is not well represented throughout literature, it has sparked interest in some researchers. Salem-Darrow, 1995, Medozi et al, 2000, Standen et al, 2001, Fittipaldi-Wert & Mowling, 2009, and Magill & Anderson, 2013 have all investigated the use of technology, serving as visual aids or prompts, in the development of motor skills in children with disabilities. Researchers have suggested that these technological visual aids are best utilized when instructing basic or simple motor skills, in comparison to complex motor patterns. While the use of technology and its integration into physical education settings is becoming more prevalent, the investigation of specific applications or programs is scarce.

One review has been published regarding a specific technology-based visual aid. This specific technology, Exercise Buddy (Exercise Buddy, LLC), is an electronic visual exercise system that has been designed specifically for children with intellectual disabilities or sensory processing impairment (McDonald & Wegis, 2016). The published review expresses that Exercise Buddy is portable and accessible. While virtually no literature has explored the use of exercise buddy and its effect on motor skill development, authors of the review claim that Exercise Buddy could potentially help to bridge the gap between technology interventions and motor skill development in children with disabilities (McDonald & Wegis, 2016).

There is an obvious gap in research regarding the use of technology and motor skill development in children with both intellectual and physical disabilities. Therefore; the purpose of this study was two-fold: 1) to add to the body of literature observing the effectiveness of Exercise Buddy, visual exercise system and 2) to determine psychometric values of the TGMD-2 in participants with varied disabilities. It was hypothesized that Exercise Buddy would contribute to significant locomotor skill development in children with diagnosed sensory impairments and the TGMD-2 would have excellent test-retest reliability.

CHAPTER II

REVIEW OF LITERATURE

Sensory Processing & Sensory Impairments in Individuals with Diagnosed Disabilities

In 2011, it was reported that in the United States, between 5% and 16% of all preschool-aged children were diagnosed with a sensory processing disorder (James et al, 2011). A sensory processing disorder, or sensory impairment, is any difficulty in the perception or organization of visual, auditory, gustatory, olfactory, vestibular, tactile, or proprioceptive information processed by the central nervous system (Dunn, 2001). Because children diagnosed with sensory impairments often have altered responses to various stimuli, growth and development of these children are often hindered. Frequently, sensory processing disorders are evident in children who have also been diagnosed with an intellectual or physical disability (Newschaffer et al, 2007).

According to the American Association on Intellectual and Developmental Disabilities, an intellectual disability is any disorder that impairs the general mental capacity of an individual (Schalock et al, 2012). Intellectual disabilities may include, but are not limited to autism spectrum disorder, pervasive developmental disorders – not otherwise specified (PDD-NOS), and Down Syndrome. These intellectual disabilities are reported to be the most commonly diagnosed (Newschaffer et al, 2007). Diagnosis is performed by a certified medical professional, such as a licensed psychologist or medical doctor (Zander et al, 2015).

Diagnosis

Criterion for intellectual disability diagnosis lies within the Diagnostic and Statistical Manual, fifth edition (DSM-5). The DSM-5, revised and published in May 2013, is structured for the diagnosis of intellectual disabilities by providing appropriate licensed medical practitioners with a list of characteristics and behaviors associated with various intellectual disabilities (Zander et al, 2015). Currently, the DSM-5 is one of the most utilized assessment tools when evaluating and diagnosing individuals with intellectual disabilities, however, concern regarding poor sensitivity of the DSM-5 has been noted. In a study where the DSM-5 criteria for autism spectrum disorder was applied, a 23 – 54 % reduction in diagnostic sensitivity relative to autistic behavior in children was revealed. Researchers of this study further revealed that the DMS-5 sensitivity was lower in high-functioning subjects, compared to low-functioning subjects (Zander et al, 2015). These findings suggest that DSM-5 may exclude those individuals with higher cognitive abilities.

Autism Spectrum Disorder

Autism spectrum disorder, or ASD, is defined as a group of neurodevelopmental disorders characterized by deficits in three core domains; social interaction, communication, and repetitive behavior (Newschaffer et al, 2007). Currently, ASD is the most common intellectual disability, with around 1 in every 68 children, aged 8 and younger, diagnosed each year, via DSM-5 criterion (Montigney et al, 2017). In past years, researchers have reliably been able to diagnose ASD in children as young as two to three years of age (Lord, 2006). Research remains unclear of the precise etiology of ASD, but suggest possible link to pre- and post-natal conditions such as low birth weight, infection, advanced maternal age, and poor maternal diet (Berry et al, 2013). Common characteristics of ASD include but are not limited to restrictive or repetitive behavior, verbal outburst, self-injurious behavior, and sensory impairments (Newshaffer et al, 2017). The sensory impairments in children diagnosed with ASD can present on a wide spectrum, from difficulty in auditory processing, balance/coordination deficits, and visual or auditory hyper-sensitivity (Gresham, 2010). It's important to recognize that not all children diagnosed with ASD present with identical sensory impairments.

Pervasive Developmental Disorders – Not Otherwise Specified

Pervasive developmental disorders – not otherwise specified, or PDD-NOS, is often associated with, or considered a subgroup of, ASD, although some distinct differences have been noted. PDD-NOS is diagnosed in children who have delayed language and communication, fewer repetitive behaviors, but higher social integration and functioning, compared to those who are diagnosed with ASD, via DMS-5 criteria (Hassan & Perry, 2011). An article published by Fombonne in 2003 suggested that PDD-NOS was diagnosed in approximately 15 out of every 10,000 children (Fombonne, 2003). Research has suggested that the etiology of PDD-NOS is comparable to ASD (Berry et al, 2013). Also, much like ASD, PDD-NOS can be demonstrated on a spectrum of severity. Research has observed children diagnosed with PDD-NOS exhibit the same sensory impairments to that of children diagnosed with ASD, but more often have extreme difficulty when processing and verbally addressing emotion (Walker et al, 2004). Literature suggests that as children age, a diagnosis of PDD-NOS may be reformed to ASD, if specific symptoms and characteristics, such as extreme repetitive behaviors, decreased social function, or a greater deficit of language delay, develops (Lord et al, 2000).

Down Syndrome

Another intellectual disability that has a high co-morbidity of sensory impairment is Down Syndrome. Down Syndrome is widely recognized as the most prominent chromosomal abnormality, occurring in 1 out of every 1,000 live births (Nadkarni et al, 2012). Because Down Syndrome, unlike ASD and PDD-NOS, is a chromosomal abnormality, and is diagnosed via blood test, the exact etiology of the abnormality has been widely researched (Elmaksoud, 2016). When the 21st pair of chromosomes is being produced, faulty cell division influences the duplication of hereditary material (Dykens et al, 2000). The duplicate hereditary material that is found on the 21st chromosome is what influences the development of Down Syndrome. Down Syndrome is associated with deficits in motor and cognitive abilities. Those diagnosed with Down Syndrome often have poor balance, hyper-mobility, underdeveloped fine motor skills, and impaired perception of sensory input (Savelsbergh, 2000).

Many intellectual disabilities are linked to a sensory processing disorder, or sensory impairment, and comparably, various physical disabilities share the same association. A physical disability is defined as any condition that inhibits or restricts one's dexterity, mobility, ambulation, or stamina (Wright, 1983). Examples of physical disabilities that are linked to sensory processing impairments are cerebral palsy and traumatic brain injury. Both of these physical disabilities are the result of damage to the brain and can leave permanent motor, cognitive, or sensory impairments (Oskoui, et al, 2017).

Cerebral Palsy

Cerebral palsy, or CP, is identified as a group of non-progressive neuromotor disorders that occur in an early stage of life (Oskoui et al. 2017). Occurring in 2 out of every 1,000 live births, CP is recognized as the most common cause of chronic physical disability in children (Oskoui et al, 2013). The exact knowledge of the specific incidence that results in CP is not always know, as many possible events can result in brain damage; such as oxygen deprivation, poisoning, bacterial infection, or underdevelopment of brain tissue (Gormley, 2001). Observational research has suggested that children diagnosed with CP often have various associated sensory impairments such as temperature hyper-sensitivity, decreased audio or visual perception, or limited proprioceptive awareness (Ostensjo, 2004). While CP occurs in predominantly children, traumatic brain injuries can affect persons of all ages.

Traumatic Brain Injury

Traumatic brain injury, or TBI is defined as acute damage to brain tissue (Faul, 2010). Unlike the chronic nature of CP, TBIs can occur in sudden events such as collisions, falls, or blunt force trauma. Globally, adolescents between ages 15 – 19, and adults over 65 years are the most likely to sustain a TBI (Faul, 2010). Brain damage is evaluated using medical imaging, specifically a computed tomography (CT) or magnetic resonance imaging (MRI). Following the evaluation of severity in brain damage, a TBI is then diagnosed using a series of neurological, cognitive, and motor assessments (Graham, 2000). Due to the similar nature in deficit seen in CP and in TBIs, research has observed the same notable sensory impairments present in both populations (Ostenjo, 2004).

As explored by research, sensory processing disorders, or sensory impairments can accompany several intellectual and physical disabilities. While the severity and type of impairment may differ in each person diagnosed with one of these disabilities, research supports that without intervention, sensory impairments can decrease quality of life.

Results of Poor Motor Skill Development in Children with Sensory Impairments

Compared to those who are typically developed, children who have been diagnosed with sensory impairments associated with a disability have shown to be underdeveloped in fundamental motor skills (Leonard & Hill, 2014). These fundamental motor skills include subgroups of locomotor movements and object control paradigms. Examples of locomotor movements include, but are not limited to running, jumping, hopping, and galloping; while object control skills may include dribbling, throwing, catching, or rolling a ball (Ulrich, 2000). Because of frequent underdevelopment in these fundamental skills, children with disparities in sensory function often suffer from decreased academic success, failure of social inclusion among same-aged peers, and diminished health status (Macdonald et al, 2017). Within the past several years, research has explored, in detail, the aforementioned limitations children with various sensory impairments experience.

Academic Success

The relationship between academic success and motor skill development has been heavily researched in children with atypical development. Well established motor skills have been linked to increased cognitive function, as well as academic performance in education-based areas such as mathematics, reading, and language (Burns et al, 2004). The foundation behind the suggestion that motor skill development is linked to academic and cognitive abilities stem from evidence provided by neuroimaging. During both cognitive and physical tasks, the prefrontal cortex, basal ganglia, and cerebellum are activated (Diamond, 2000; Willingham, 1999). The prefrontal cortex is commonly associated with cognitive function, while the cerebellum is linked to motor function. Often, in individuals diagnosed with sensory processing disorders or sensory impairments, evidence has surfaced of an overlap of these structure's functions (Diamond, 2000). Because the function of these structures are suggested to overlap, researchers have explored the linkage between motor skill development and academic success.

In 2013, Carlson et al explored the link between fine motor skills and academic achievement. During this study, 97 participants, all diagnosed with disabilities associated with visual impairments, completed testing measures to evaluate visual-motor integration, intelligence, and achievement. Visual-motor integration was assessed by the completion of the Beery-Buktenica Developmental Test of Visual-

Motor Integration (Beery & Beery, 2006). Academic achievement of the participants was evaluated by the Woodcock-Johnson Tests of Achievement (McGrew & Woodcock, 2001). Participant achievement was analyzed for mathematics, reading, and oral language. Results of data analysis depicted low significance between mathematic achievement and visual-motor integration ($p < .01$). In respect to reading achievement and visual-motor integration, low significance was found ($p < .03$). The analysis of oral language achievement and visual-motor integration produced the most significance ($p < .05$). Results of this study suggest those with visual impairments perform significantly in language-based related education. This study is one example of researchers exploring the linkage between motor skills (fine or gross) and academic success.

A study completed by Magistro et al observed the relationship between motor skill development and academic success in atypically developed third-grade students. Researchers assessed fundamental gross motor skills (locomotor and object control) of 68 participants who had a previous diagnosis of atypical development. Participants motor skills were assessed by criteria found on the Test of Gross Motor Development (Ulrich, 1985). Following assessment of participant's motor skill, academic success and achievement was addressed. Curricular instructors completed a Likert-scale, self-report questionnaire assessing the academic standings of the participants, in comparison to their typically-developed, same-aged peers. Analysis of the collected data suggested a significant correlation ($p = .053$) between the participants who scored high on both motor skill and academic success evaluations (Magistro et al, 2015).

Social Inclusion

Social inclusion is defined as engagement and participation in society as a means of improving quality of life and reducing social isolation (Oxoby, 2009). Researchers have expressed the multitude of benefits associated with social inclusion and the development of motor skills in those diagnosed with sensory impairments. These benefits may include, but are not limited to facilitation of relationship-building, increase in self-confidence, increase in expressed desire to engage in play-time activities, and increase in enjoyment of time spent with same-aged peers (Carvalho et al, 2014). The theory of *learning to learn* is the framework in which the importance of motor skill development and social inclusion is built (Adolph, 2005). At an early age, children develop fundamental motor skills and learn the importance of applying those motor skills in activities of everyday life. These activities of everyday life include learned social behaviors and the seeking out of social inclusion (Adolph, 2005). Much research has been conducted on social inclusion and the development of motor skills in children diagnosed with sensory impairments.

Physical education in a structured setting is a great vehicle to deliver the instruction required to develop motor skills. Children, with or without disabilities, can learn motor skills during physical education classes while attending primary school (Place & Hodge, 2001). These physical education classes are great opportunities to facilitate social inclusion between typically developed and atypically developed students. A case-study conducted by Place and Hodge observed the motor skill development and social inclusion of three primary-school-aged subjects placed in an integrated physical education class. An integrated physical education class is one in which students with and without disabilities are included. Inclusion-based setting are suggested to prompt the best results of social integration (Block and Malloy, 1998). During this study, data was collected by video analysis, observation, and subjective interview given by the physical education instructor. Over a period of 6 weeks, the physical education class participated in activities that prompted the development of gross motor and object control skills; such as running, jumping, sliding, and dribbling, kicking, and throwing a ball. At the end of the 6-week testing period, video analysis to determine the levels of motor skill presentation and social integration was completed. Video analysis revealed that as the students with disabilities performed motor skills correctly, their typically-developed peers were more inclined to initiate conversation and inclusion. Interview by the physical education instructor corroborated the video analysis findings. Results from this study persuaded researchers to suggest the correlation between successful motor skill development and execution, and social inclusion by typically developed same-aged peers (Place and Hodge, 2001). Fundamental motor skill development in children with sensory impairment associated disabilities possess the opportunity to manifest into even greater skill development.

The development of motor skills can transpire into the development of sport-specific skills, which can then facilitate the exploration of sport integration. Unified Sports is a globally acknowledged initiative to integrate those diagnosed with disabilities into sport teams comprised of typically-developed individuals (Dowling et al, 2012). A qualitative study conducted by McConkey et al observed the social inclusion factors presented during Unified Sport events such as practices, exhibitions, and games. Over 1,600 Unified Sport athletes were identified, and asked to give a subjective analysis of their experience during Unified Sport events. During their analysis of experience, participants were urged to focus on the factors that prompted social inclusion among the athletes with disabilities and their typically-developed peers. Researchers concluded that the following themes were commonly suggested by interviewees to prompt social inclusion: development of athlete and partner personal and sport skills, positive perception of athletes, inclusive and equal bond between teammates, and building alliances between families, schools, and the community (McConkey et al, 2012). In closing, McConkey et al suggested that had motor skills not been developed in athletes with disabilities, they would not have reaped the social benefits associated with this study.

Health Status

In 2000, it was reported that people with intellectual and physical disabilities are more likely to lead an unhealthy lifestyle and be overweight or obese, compared to the general population (Gravestock, 2000). Obesity, or being overweight, is a chronic condition that is associated with many co-morbidities such as cardio vascular disease, hypertension, diabetes, and certain cancers (Sugerman, 2005). To decrease the risk of developing an unhealthy lifestyle, motor skill development and physical activity need to be implemented in individuals with disabilities. Overall heath status and quality of life in children with disabilities is a topic of interest among researchers. Bray et al investigated the correlation between low motor function and health-related quality of life (HRQoL) in children with diagnosed motor impairment. HRQoL is the perceived impact of health status on quality of life, in the domains of physical, psychological and social functioning (Leidy et al, 1999). In a 15-question Likert-scale assessment, completed by the participant's parents/caregivers, researchers collected information regarding participant's mobility, self-care, usual activities, associated health conditions, pain and discomfort, and anxiety and depression. Data analysis suggested a strong degree of consensus between the severity of mobility impairment and lower diminished HRQoL. Results of this study persuaded researches to suggest a direct relationship between poor motor skill development or function, and low quality of life (Bray et al, 2017). Research is HRQoL of children with diagnosed disabilities and sensory impairments is well represented. Chen et al in 2011, and Canty-Mitchell et al in 2005, completed similar studies based on children with impairments and their associated HRQoL. Participants in Chen et al's study met inclusion criteria of being under the age of 18 and currently receiving health care services for a diagnosed intellectual or physical disability (Chen et al, 2011). In comparison, participants in Canty-Mitchell et al's study were children under the age of 12 and diagnosed with an impairment in sensory processing (Canty-Mitchell et al, 2005). Both studies utilized a 12-question assessment that evaluated domains of physical, psychological and social functioning. Per methodologies of both studies, assessments were to be completed by the parent/caregiver of the participant. Like results of the study completed by Bray et al, these studies produced results suggesting children with higher severity disabilities or impairments will present with a lower HRQoL (Chen et al, 2011, Canty-Mitchell et al, 2005). These studies provide considerable evidence of the correlation between mobility, motor skill development, and quality of life.

The evidence supporting the detrimental effects of underdeveloped motor skills in children with sensory impairments and disabilities is irrefutable. In summary, underdeveloped motor skills can facilitate poor academic success, exclusion from social interaction, and a poor heath related quality of life.

Test of Gross Motor Development

As previously discussed, fundamental motor skills, or goal-based movement patterns are developed in early childhood, and are the precursor to complex motor skills and sport-specific skills (Burton & Miller, 1998). Considering the importance in the development of fundamental motor skills, evaluation and assessment of these skills is essential in children diagnosed with disabilities. Monitoring the development of motor skills in children with disabilities can lead to the identification of specific developmental delays and impairments, and can subsequently be useful in the implementation of individualized education plans for that child (Gallahue & Ozmun, 1998, Jansma & French, 1994).

The Test of Gross Motor Development - second edition (TGMD-2) is one of the most utilized assessment tools when observing motor skill development in children with disabilities. The TGMD-2 can be utilized in children as young as 3 years of age who are typically developed, or present with intellectual or physical disabilities (Ulrich, 200). While the TGMD-2 is designed for evaluation of all children, typically or atypically developed, this assessment tool is most commonly used for children who are atypically developed (Ulrich, 2000). The TGMD-2 is a composite of 12 subtests of motor skills; 6 locomotor skills and 6 object control skills. The locomotor skills found on the TGMD-2 are run, hop, gallop, slide, leap, and horizontal jump; the object control skills being underhand roll, striking a stationary ball, stationary dribbling, overhead throw, catch, and kick (Ulrich, 2000). Each subtest listed has many associated performance-based criteria that must be evaluated when completing the assessment. Ulrich suggests the TGMD-2 has testing sensitivity of 10 weeks, meaning, most accurate results of motor skill development can be assessed after a 10-week period between evaluations (Ulrich, 2000). Psychometrics of the TGMD-2 are evident throughout published literature.

Evidence of sufficient reliability and validity of the TGMD-2 in children with various disabilities has been established. A study completed in 2010 observed the reliability and validity of the TGMD-2 in children with visual impairments (Houwen et al, 2010). Researchers facilitated the completion of the TGMD-2 in 50 participants, between ages 6 – 12, diagnosed with a visual impairment. Internal consistency of the locomotor and object control raw scores was established by the calculation of Cronbach's alpha. A Cronbach's alpha of .70 was established, and was deemed acceptable by the research team. Interrater, intrarater, and test-retest reliability were analyzed using the intraclass correlation coefficient (ICC) finding that the ICCs for each metric were .82 (interrater), .85 (intrarater), and .86 (test/re-test) (Houwen et al, 2010). Results produced what researchers accepted as statistically significant ($p < .05$), and ranged from 0.32 to 0.76, respectively. Results of this study suggests a high reliability and validity in the TGMD-2, for children with visual impairments (Houwen et al, 2010).

A vast body of literature supporting similar findings to that of Houwen et al can be found. Portney & Watkins, 1993, Parkkinen & Rintala, 2004, and Simons et al., 2008, all completed studies that evaluate the validity and reliability of the TGMD-2 in children with varying disabilities. Portney & Watkins observed children diagnosed with physical disabilities and limited motor function, Parkkinen & Rintala observed children diagnosed with intellectual disabilities, and Simons et al observed children who were typically developed. The results of these three studies mirrored the findings of Houwen et al, in that comparably high ICC's, between 0.70 – 0.92 respectively, were produced. (Portney & Watkins, 1993, Parkkinen & Rintala, 2004, and Simons et al., 2008). Literature supports high reliability and validity in respect to the TGMD-2 as a vehicle of assessment for motor skills of children, typically or atypically developed.

Technology and Motor Skill Development

There is no denying that wireless technology has evolved over the years; consider that the first iPad was released in 2010. Some educators even argue that it has become a critical tool in delivering an effective and comprehensive education to students of all ages and abilities (McDonald & Wegis, 2016). Technology has the capabilities of being adapted to fit the needs of many educational areas; such as but not limited to core content (math, reading, writing, etc.), health and consumer sciences, and physical education (Obrusnikova & Rattigan, 2016). Although the topic of technology use and physical education/motor skill development, specifically in students with disabilities, is not well represented in literature at this time, it is gaining the attention of researchers.

There have been extensive reports of educators utilizing visual prompts during the acquisition of motor skills in students with intellectual or physical disabilities. Literature suggests that educators will most commonly utilize electronic visual prompts when instructing specific or basic movements, in comparison to complex movements (Salem-Darrow, 1995, Medozi et al, 2000, Standen et al, 2001, Fittipaldi-Wert & Mowling, 2009, Magill & Anderson, 2013). Simple movements include fundamental motor skills such as running, jumping, sliding, leaping, hopping, or galloping. While literature supporting the use of technology as a visual aid for motor skill development exists, literature supporting specific electronic-based applications is scarce.

In 2016, a review of a newly developed electronic visual aid was published. The review examined Exercise Buddy (EB), an electronic visual exercise system, that has been designed specifically for children with disabilities (Mcdonald & Wegis, 2016). While using existing up-to-date physical fitness standards, EB allows for a completely individualized approach to fitness-related skill instruction, including motor skill development. The review continues to suggest that this application provides peer-modeled visual demonstration, through brief video clips, of specific exercises (i.e. lunges, running, bicep curls, jumping, etc.). Video models on EB are also accompanied by verbal cues, to further potentially increase effectiveness of instruction. The authors express a primary advantage of EB lies within its portability and accessibility. EB is available for download on multiple mobile devices and operating systems (McDonald and Wegis, 2016). Currently, evidence supporting Exercise Buddy and its effectiveness as a visual exercise system is unavailable.

Future Considerations

With the appeal of technology being used for educational tools on the rise, it is imperative to explore all possibilities when advocating for the development of motor skills in children with disabilities. Currently, there is a gap in literature to support the use of electronic visual aids in development of these fundamental motor skills. In addition to this broad gap in literature, it is recommended that further evaluation of the Exercise Buddy visual exercise system should be completed (McDonald and Wegis, 2016).

Purpose of Study, Hypothesis, Limitations

The purpose of this study was to add to the sparse body of literature observing the effectiveness of Exercise Buddy, visual exercise system. This study also aimed to determine psychometric values for participants with varied disabilities. It was hypothesized that Exercise Buddy will contribute to significant locomotor skill development in children with diagnosed sensory impairments. It was also hypothesized that interrater reliability of the TGMD-2 will be excellent.

It can be assumed that due to the time allotted for the completion of this study, the sensitivity of the TGMD-2 was not observed. While the TGMD-2 has a testing sensitivity of 10 weeks, the time constraint of this study allow a pre-to-post testing window of 6 weeks. To extend on limitations related to the TGMD-2, due to the subjective nature of the evaluation, it can be assumed that inter-evaluator perception may differ. Finally, a limitation of potential lack of participant motivation and appearance of poor attitude is acknowledged, as it may become a deterrent for quality performance of the tasks required.

CHAPTER III

METHODS

Participants

A total of 8 children, between the ages of 7 and 14 years old with a previous diagnosis of sensory impairment related to an intellectual or physical disability participated and completed this study. Participants were recruited from the Kentucky Adapted Physical Education (KAPE) program, located in eastern Kentucky. Permission to recruit participants from the program was granted by the program coordinator. The parents/caregivers of the participants were approached during a scheduled meeting time of the KAPE program and were verbally recruited by the primary researcher. During verbal recruitment, the primary researcher explained inclusion criteria to be as follows: (a) previous diagnosis of sensory impairment related to a disability (physical or intellectual), (b) between the ages of 6 – 16 years old, and (c) enrolled in the KAPE program. Participants were excluded from this study if no previous diagnosis of sensory impairment was present. Descriptive statistics for participants are found in Table 1.

Table 1. Descriptive Statistics of Participants

Age (in years)	
Mean (Standard Deviation)	10.75 (2.5)
Range	7-14
Sex	
Male	5 (63%)
Female	3 (37%)
Diagnosed Disability	
Autism Spectrum Disorder	3 (37.5%)
Traumatic Brain Injury	2 (25%)
Cerebral Palsy	1 (12.5%)
Down Syndrome	1 (12.5%)
Angelman's Syndrome	1 (12.5%)

Procedures

This observational, longitudinal study was completed over 6 weeks. This research study coincided with scheduled KAPE sessions, which occurred for 2 hours, 1 day per week. Prior to commencement of the study, the primary researcher provided a practical application training of the TGMD – 2, locomotor subtest skills only, to volunteers who assisted with data collection. During this training, the evaluation and scoring methods were explained, and adequate time for application practice was provided.

During the first scheduled session of this study, methodology was explained to parents/guardians of recruited participants, all risk factors associated with this study were explained, and parent/guardian informed consent was obtained.

Following the procurement of informed consent, the research team and trained research volunteers independently completed a baseline TGMD-2, locomotor subtest only, evaluation of each participant. Each research volunteer was assigned to a respective participant for the duration of the baseline testing. The research volunteer then prompted the participant to execute the required skill as indicated on the TGMD-2. Testing stations were created for each locomotor subtest found on the TGMD-2; run, gallop, leap, horizontal jump, slide, and hop. The testing stations were set up inside a gymnasium, and specified to the exact recommendations of set-up found on the TGMD-2 assessment form (Ulrich, 2000). Each skill assessed has several associated performance criterion that is to be exhibited by the participant during completion of the respective skill. To score individual skills, evaluators would put a "1" in the score box if the participant executed the performance criteria related to that skill correctly, or a "0" if they did not. Individual performance criteria scores were added to form a total score for each skill. Each skill score total was added together to form a RAW score.

In the next four scheduled KAPE sessions, the primary researcher initiated a separate locomotor-skill based intervention station, incorporated into the KAPE program's scheduled activities. This station utilized the visual exercise system, Exercise Buddy (EB). Video representation of specific skills was shown to each participant and was available for viewing via overhead projection onto a blank wall, or via a hand-held tablet device. The primary researcher was the main facilitator of the EB intervention station with the aid of verbal cues given to the participant from the trained research volunteers. Similar to the baseline evaluation, EB sessions were set-up to satisfy the requirements found on the TGMD-2.

For three out of four intervention sessions, two specific locomotor skills were emphasized using EB, based on the timeline constraint of the study, and the time allotted by the KAPE program. On the fourth intervention session, all locomotor skills found on the TGMD-2 were re-emphasized. During intervention sessions, participants were required to remain at the EB station until they completed the emphasized locomotor skills four times. Once the participants completed the required tasks, they could resume participating in KAPE's scheduled activities.

Re-evaluation of participant locomotor skills occurred on the 6^{th} scheduled session of this study. Methodologies of this evaluation mirrored the baseline evaluation testing where the participants were asked to perform a task and the research team and volunteers completed the TGMD-2 assessment. Table 2 depicts the time-line of this study.

Table 2. Timeline of study

Session #	TGMD-2 Pre-test	Run	Gallop	Leap	Horizontal Jump	Slide	Hop	TGMD-2 Post-test
1	x							
2		x	x					
3					x		x	
4				x		x		
5		x	x	x	x	x	x	
6								x

Data Analysis

Descriptive statistics were calculated with continuous variables reported as means and standard deviations and categorical variables reported as counts and percentages. Interclass correlation coefficients (ICC), standard error of measurement (SEM), and minimal detectable change at the 95% confidence level (MDC_{95}) were calculated to evaluate test-retest reliability between research team and research volunteer completed TGMD-2 assessments. The research team observes that ICC values over .70 are considered excellent. Cohen's kappa was performed to evaluate agreement between pre-and post-test evaluations from both the research team and research volunteers. The research team observes that kappa values below .40 are minimal, between .40 - .59 are weak, .60 - .79 are moderate, .80 - .90 are strong, and any value above .90 are almost perfect (McHugh, 2012). Paired sample t-tests were used to evaluate locomotor skill improvement in response to Exercise Buddy intervention. Statistical significance was determined to be $p<0.05$. All statistical procedures were performed with SPSS 24 statistical software (IBM, Armonk, NY).

CHAPTER IV

RESULTS

Interclass Coefficient Correlation

The reliability results for individual locomotor skills, as well as the raw score of the subtest, are shown in Table 3. For the purpose of this study, the research team recognizes any ICC value over .70 to be considered good, and any value over .80 to be considered excellent. As depicted by Table 3, ICC values for all evaluated measures were ≥.82 which are considered excellent.

Table 3. ICC, SEM, MDC_{95}

	Run	Gallop	Hop	Leap	Horizontal Jump	Slide	RAW
ICC	.939	.969	.958	.821	.851	.986	.993
SEM	.8	.6	.7	1.1	1.2	.45	1.6
MDC_{95}	2.2	1.6	1.9	3	3.3	1.2	4.4

* ICC = Interclass Coefficient Correlation,
* SEM= Standard Error of Measure
* MDC_{95} = Minimal Detectable Change at the 95% Confidence Interval

Cohen's Kappa

Table 4 depicts kappa values for both pre-test and post-test performance criteria measures, as well as the interpretation of those values. Kappa values that are below .40 or between .40 - .59 were considered weak, .60 - .79 were considered moderate, .80 - .90 were considered strong, and any value above .90 was considered almost perfect.

Table 4. Kappa Values of Pre-Test and Post-Test Performance Criteria

	Pre-Test Kappa	Interpretation	Post-Test Kappa	Interpretation
Run PC 1	.714	Moderate	.714	Moderate
Run PC 2	.467	Weak	.200	Weak
Run PC 3	.600	Moderate	.07	Weak
Run PC 4	.75	Moderate	1	Almost Perfect
Gallop PC 1	.771	Moderate	.714	Moderate
Gallop PC 2	.750	Moderate	1	Almost Perfect
Gallop PC 3	.333	Weak	.750	Moderate
Gallop PC 4	.629	Moderate	.543	Weak
Hop PC 1	.750	`Moderate	.130	Weak
Hop PC 2	.556	Weak	1	Almost Perfect
Hop PC 3	.273	Weak	.750	Moderate
Hop PC 4	.543	Weak	1	Almost Perfect
Hop PC 5	.500	Weak	.543	Weak
Leap PC 1	.750	Moderate	.158	Weak
Leap PC 2	.294	Weak	.400	Weak
Leap PC 3	.600	Moderate	.385	Weak

Table 4. (continued)

Horizontal Jump PC 1	.091	Weak	.179	Weak
Horizontal Jump PC 2	.484	Weak	.500	Weak
Horizontal Jump PC 3	.429	Weak	.714	Moderate
Horizontal Jump PC 4	.226	Weak	.714	Moderate
Slide PC 1	.778	Moderate	.619	Moderate
Slide PC 2	.771	Moderate	.556	Weak
Slide PC 3	.778	Moderate	1	Almost Perfect
Slide PC 4	.778	Moderate	.778	Moderate

* PC = Performance Criteria

Pre-and Post-Test Comparison of Locomotor Skill Development

No statistically significant findings were present when comparing the TGMD-2 scores from before to after the introduction of EB to the sessions. Overall, after the intervention, post-testing revealed 4 subjects decreased in locomotor skills presented, and 4 subjects remained the same, as compared to pre-test evaluations.

CHAPTER V

DISCUSSION

The aim of this study was to observe locomotor skill development in children diagnosed with sensory impairments as a result of a disability. Through the use of the TGMD-2, locomotor subtest only, motor skills were evaluated pre-and post-intervention. After disseminating the results, there is evidence to accept the hypothesis that inter-rater reliability would be excellent. However, the hypothesis that locomotor skill development would improve as a result of the implementation of Exercise Buddy was rejected.

Interrater Reliability

The excellent reliability found in this study for the TGMD-2 adds to the already established body of literature supporting high ICC values associated with the TGMD-2 (Parkkinen & Rintala, 2004, and Simons et al., 2008). Although the sample size was small, the findings are externally valid due to the various diagnoses included in this study. It is recommended that future research exploring interrater reliability in the use of the TGMD-2 evaluate a larger number of subjects of various ages and disability levels simultaneously in order to verify the findings of the current work.

Cohen's Kappa – Agreement

When examining the results of the analysis of Cohen's kappa, it is evident that overall agreement of individual performance criteria found within the TGMD-2 assessment is variable. Due to the subjective nature of the assessment, these findings coincide with a study completed by Palmer & Brian in 2016. In their study, Palmer and Brian evaluated the kappa value of agreement between professional and novice evaluators, in respect to the completion of the TGMD-2 in children with intellectual disabilities. Results of their study revealed a low kappa value, or agreement, between evaluators. In comparison, results of this study produced a range of kappa values; minimal (N = 5), weak (N = 18), moderate (N = 20), almost perfect (N = 6). Palmer & Brian suggest that a more in-depth training of novice evaluators be performed prior to assessment of children (Palmer & Brian, 2016). The research team agrees with Palmer & Brian, and prior to evaluation of participants, a more in-depth training of research volunteers should have been performed. Tools such as instructional videos can be utilized during TGMD-2 method training of novice evaluators to increase comprehension of evaluation methods. Given a more in-depth training be provided before data collection, kappa values may have supported a greater level of agreement.

Exercise Buddy

Exercise Buddy visual exercise system is a newly developed technology-based visual aid that can assist the facilitation of motor skill development in children with disabilities (MacDonald & Wegis, 2016). For the purpose of this study, Exercise Buddy was used as an intervention, in hopes to increase the development of locomotor skills in participants. Results showed no significant increase in locomotor skill development among participants; following intervention, 4 participants declined in demonstrated locomotor skills, 3 participants showed no change, and 1 subject improved. The research team recognizes that the development of motor skills, especially in children with diagnosed disabilities, can take much longer, as compared to the development of motor skills in typically developed children (Walkley et al, 1996). Walkley et al suggests that it takes between 240 and 600 minutes of instruction to teach a child to correctly perform a fundamental motor skill. It is recommended that instruction take place multiple days a week, for 30 – 45 minutes at a time. Sidaway et al, 2012 also suggests that for simple tasks, more practice and less feedback is better for typically developed kids. The researchers of this study believe that if intervention was extended for a longer period of time, more significant results would be produced. Intervention within this study took place one day a week, for a maximum of 20 minutes. This time limitation is thought to be the confounding variable in the failed development of locomotor skills among participants.

In conjunction with this confounding variable, consider the “use it or lose it” principle, or the evidence behind muscle memory and skill retention. Previous research suggests human skeletal muscle has high plasticity, and can adapt to various movements, when continuous effort is given to developing that plasticity (Egan, 2013). Recognizing this, and applying it to the methodology of the current study, it is evident to see that specific motor skills were emphasized during early sessions, and not re-emphasized until final sessions. Because they were not actively being emphasized, the participants were not exposed to further instruction and practice of these skills, therefore decreasing potential ability to enhance muscle plasticity, and ultimately, proficiently execute and master these skills. The researchers acknowledge the potential of further skill development had more frequent instruction occurred for each skill evaluated.

Furthermore, findings of the current study did not support the effectiveness of Exercise Buddy. Although the current methodology did not utilize a randomized control trial format, it is recognized by the researchers that to future evaluate the effectiveness of Exercise Buddy, methodologies associated with the format of a randomized control trial may prove beneficial for evaluating true intervention-facilitated improvement.

Limitations

Limitations of the current study include limited sample size, participant attitude, behavior and participation during sessions, and the subjective nature of the TGMD-2 evaluation. The subjective nature of the TGMD-2 evaluation can be overcome by offering a more in-depth and extensive training for novice evaluators. This training should include visual demonstration, verbal instruction, and adequate practical application practice. Limited sample size and attitude and behavior of participants, while acknowledged as significant limitation of this study, is a limitation seen among much research with special populations. This limitation is seldom avoidable, but should be mentioned.

Researchers of the current study recommend future considerations for further investigation. A larger sample size would prove useful when evaluating the overall effectiveness of Exercise Buddy, visual exercise system. Having a larger sample size would increase the representation of various disabilities, providing additional insight to the prevalence of diagnosed disabilities associated with sensory impairment and motor function deficit. It is also recommended that more time be allotted for further research. The investigators suggest that adhering to the TGMD-2's testing sensitivity of a minimum 10 weeks will allow time for further development of motor skills, and could lead to more significant skill execution and mastery. Finally, if future research methodologies utilize novice evaluators for data collection, it is recommended that more in-depth training procedures be completed.

In conclusion, the research team found no differences in motor skill development following the implementation of Exercise Buddy. Although no differences were found, MDC_{95} values have now been established. Lastly, findings of this study persuade the research team to acknowledge the TGMD-2 is a reliable tool that can be used to assess motor skills in a variety of diagnoses.

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