IDIOPATHIC TOE WALKING AND POSTURAL INSTABILITY: THE NEXT STEP

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BY

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DEDICATION

For Dylan McHugh, my husband, and our children Garrett, Ada, and Malia.
Thank you for your support and understanding throughout this process.

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ABSTRACT

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PURPOSE: The purpose of this study was to compare the proprioceptive system and postural control of children who walk on their toes and children who do not exhibit this gait pattern. The study had two objectives: 1) determine if children who exhibit an idiopathic toe walking (ITW) gait pattern exhibit differences in four positions when compared to non-toe walking peers, and 2) determine if there is a difference in response to everyday sensory challenges as reported by parents using the Sensory Processing Measure Home Form (SPM-Home) or Sensory Processing Measure-Preschool Home Form (SPM-P Home).

METHODS: Idiopathic toe walkers (n=15) and controls matched for age and gender (n=15) were evaluated using the following clinical observations: Schilder's arm extension test, wall squat, supine flexion, and prone extension along with the SPM-Home or SPM-P Home in order to determine differences in sensory processing, namely proprioception and postural control.

RESULTS: Significant differences were found between idiopathic toe walkers and non-toe walking peers in three postural control positions: wall squat (p=.003), supine flexion (p=.026), and prone extension (p=.021). The final postural control position, Schilder's

Arm Extension arm position, revealed significant differences in arm position (p=.049) and disassociation approached significance (p=.062). There were no significant differences in any of the subtests of the SPM-Home and SPM-P Home when comparing idiopathic toe walkers and non-toe walkers.

CONCLUSION: This study indicates that difficulties with proprioception, namely postural control, may be factors in children with an ITW gait pattern. This research contributes to the growing body of knowledge related to ITW with a specific focus on proprioceptive systems input to ITW.

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CHAPTER I

INTRODUCTION

Idiopathic Toe Walking (ITW) is defined as decreased or absent heel strike in the contact phase of the gait cycle with no known medical cause. Toe walking, or equinus gait, is typical up to three months after independent walking and is established as a normal gait variant up to age of three years (Shulman, Sala, Chu, McCaul, & Sandler, 1997; Williams, Tinley, & Curtin, 2010b). In the absence of other neuro-orthopedic conditions, ITW beyond the age of three years is associated with developmental delays, delayed language development, and sensory processing disorders including autism (Barrow, Jaworski, & Accardo, 2011; Engelbert, Gorter, Uiterwaal, van de Putte, & Helders, 2011). Children with developmental delays, delayed language development, and sensory processing related to ITW often have difficulties adapting to, and fulfilling, life roles such as student, peer, family member, and friend. They may also experience issues adapting to environmental demands, which is necessary for functional occupational performance. Inadequate adaptation leads to poor mastery over occupational challenges. The long-term effects of toe walking include developing compensatory techniques such as out-toeing, long-term foot and lower leg changes/deformity leading to foot and leg pain, and other musculoskeletal changes (Hoppestad, 2013; Stott, Walt, Lobb, Reynolds, & Nicol, 2004). Furthermore, there are also social ramifications associated with this gait pattern. Children often report being teased and called names due to toe walking (Dilger,

2005). This research focused on one area of sensory processing, proprioception, and how difficulties registering information in this area may be associated with children walking on their toes.

Statement of the Problem

Current treatment for ITW focuses on increasing range of motion and quality of movement in the ankle and foot with mixed success. Seven to twenty-four percent of the general pediatric population walks on their toes (Engelbert et al., 2011; Williams, Tinley, Curtin, Wakefield, & Nielsen, 2014). Many studies have examined surgical and non-surgical interventions of idiopathic toe walking which focus on the ankle and/or foot range of motion (ROM) (Dietz & Khunsree, 2012; Fox, Deaken, Pettigrew, & Paton, 2006; Stricker & Angulo, 1998). A recent study on the use of botulinum toxin A injections, a common practice for the treatment of toe walking, found that there was no significant differences in function or ankle ROM for children who had these injections (Sätilä et al., 2016). Few studies have investigated the possible sensory components of idiopathic toe walking, including proprioception, and no studies have been completed to examine the postural control components (Williams et al., 2014; Williams, Michalitsis, Murphy, Rawicki, & Haines, 2013; Williams, Tinley, & Curtin, 2010a).

Statement of the Purpose

The purpose of this project was to compare the proprioceptive system and postural control of children who walk on their toes and children who do not exhibit this gait pattern. This research contributes to the body of knowledge related to idiopathic toe walking with specific focus on proprioceptive needs.

Specific Aims

The aim of this study was to determine if there is a difference in the postural control and sensory processing of children who are idiopathic toe walkers and those who are not toe walkers. The study had two objectives: 1) determine if children who exhibit an ITW gait pattern exhibit differences in time in three positions and maintenance in a fourth position that all require postural control when compared to non-toe walking peers, and 2) determine if there is a difference in body awareness between the two groups as reported by parents using the Sensory Processing Measure – Home Form or Sensory Processing Measure-Preschool Home Form. The following hypotheses were tested in this study:

1. Children with an ITW gait will demonstrate postural control difficulties as evident by differences in time in the following positions: squatting against a wall, prone extension, and supine flexion compared to non-toe walking cohort.
2. Children with an ITW gait will demonstrate postural control difficulties as evident by differences in their ability to maintain and poor position in the following position: Schilder's arm extension test compared to non-toe walking cohort.
3. Children with an idiopathic toe walking gait will have a different response to everyday sensory challenges as evident by parental responses to body awareness questions from the SPM-Home Form or SPM-P Home Form compared to the non-toe walking cohort.

CHAPTER II

BACKGROUND AND SIGNIFICANCE

This chapter presents a review of literature on research that has led to the development of the study. It will describe: (a) prevalence of ITW; (b) use of an occupation-focused model; (c) sensory processing; (d) neuroscience related to ITW and proprioception; and (e) sensory re-weighting.

Prevalence, Sensory Processing, Proprioception

Prevalence

The etiology of ITW is not well established and various causes and treatments have been reported in the literature with mixed results (Dietz & Khunsree, 2012; Fox et al., 2006; Shulman et al., 1997; Williams et al., 2010b). Currently it is estimated that 7% to 24% of the general pediatric population walks on their toes (Williams et al., 2014; Engelbert et al., 2011). Many studies have investigated the gait patterns of ITW and possible surgical and non-surgical treatments which focused on increasing foot and ankle range of motion (Dietz & Khunsree, 2012; Fox et al., 2006; Stricker & Angulo, 1998).

Toe walking has long been associated with autism (Barrow et al., 2011; Mandell, Novak, & Zubritsky, 2005; Marcus, Sinnott, Bradley, & Grey, 2010; Ming, Brimacombe, & Wagner, 2007; Persicke, Jackson, & Adams, 2014; Shetreat-Klein, Shinnar, & Rapin, 2014; Stricker, 2006; Weber, 1978). As early as 1978, Weber explored this relationship and possible causes (Weber, 1978). A recent study found that of 324 children with

autism evaluated by a university developmental pediatrician, 20.1% exhibited persistent toe walking and 12% had tight heel cords (Barrow et al., 2011). Toe walking is often used as a diagnostic screening tool for identifying children with autism. Additionally, toe walking, along with hand flapping and sustained odd play, corresponded with a diagnosis of autism at a younger age (Mandell et al., 2005). Interestingly, there is also a well-documented correlation between autism and decreased postural control (Fournier et al., 2010; Kohen-Raz, Volkmar, & Cohen, 1992; Ming et al., 2007; Minshew, Sung, Jones, & Furman, 2004; Molloy, Dietrich, & Bhattacharya, 2003; Radonovich, Fournier, & Hass, 2013; Shetreat-Klein et al., 2014).

A recent study investigated the correlation between ITW, motor skills, and sensory processing (Williams et al., 2014). They found that children who are idiopathic toe walkers performed poorer on the Bruininks-Oseretsky Test of Motor Proficiency; had a lower vibration perception threshold; performed poorer on the Standing Walking Balance subtest of the Sensory Integration and Praxis Test; and demonstrated differences in the Sensory Seeking and Low Registration subtests of the Sensory Profile when compared with non-toe walking peers. There has been little other research into the possible connection with ITW and postural control.

Use of Occupation-Focused Model

Under the paradigms of occupation and development, the guiding theoretical model for this research is Occupational Adaptation (OA). This theory postulates that as individuals become more adaptive, their occupational performance will become more

functional (Schkade & Schultz, 1992). Adaptation is a change in state due to relative mastery over occupational challenges (Schkade & Schultz, 1992).

Adaptation is an important part of the field of occupational therapy. Adaptation has been a key aspect of occupational therapy since the beginning of the profession and early founders described lack of adaption as a key problem in formidable diseases (Meyer, 1922). This concept rose as one of the solidifying components of occupational therapy and bridges the divide created by specialization in various areas of occupational therapy. Adaptation should be viewed in a temporal aspect as it changes across the life span (Huss, 1981; Kielhofner, 1977; King, 1978). When occupational therapists possess a good understanding of the basic science of occupational therapy, they can help patients become more adaptive through occupations. The use of occupations to assist with adaptation has been well documented in the field of OT and it is a client-centered process (Chan & Spencer, 2004; Spencer et al., 1998; Spencer, Hersch, Eschenfelder, Fournet, & Murray-Gerzik, 1999).

The OA model was created by a team at Texas Woman's University in the early 1990s as a way to address the need for conceptual models in the field (Schkade & Schultz, 1992). Occupational Adaptation is based on the premise that as individuals become more adaptive, they become more functional and the individual is an agent of change while the therapist is a facilitator (Schkade & Schultz, 1992; Schultz & Schkade, 1997). The model starts with two important factors: Person, who has a desire for mastery, and Occupational Environment, which has a demand of mastery. The resulting interaction is the press for mastery. This press leads to an occupational challenge,

occupational role expectations, occupational responses, and assessment of outcomes. Adaptive responses are key in meeting the occupational challenges and responding appropriately. This process includes: generation, evaluation, and integration of responses. There are three types of adaptive responses: primitive (hyperstable), transitional (hypermobile), and mature response. The goal of occupational therapy is to help individuals develop more mature adaptive responses to the press for mastery. There are also three person systems: sensorimotor, cognitive, and psychosocial. Each of these human systems are present during occupational challenges, but depending on the demands of the occupational challenge, one of the three person systems is more dominant. For toe walkers, the sensorimotor system may not be responding appropriately to the occupational challenge. This leads to the generation of an impaired adaptive response, toe walking, and integration of this impaired motor pattern.

Other common OT models describe the importance of adaptation. The Model of Human Occupations states that adaptation happens when individuals interact with the environment and occupational adaptation leads to occupational identity or a composite sense of who one is (Kielhofner, 2008). The Person, Environment, Occupation (PEO) Model defines adaptation as the process by which people confront the challenges of everyday life. The interaction between the person, environment, and occupation is viewed as overlapping circles with the overlap representing occupational performance. A small overlap represents a poor fit, which leads to discontentment and frustration. Adaptation is necessary in order to increase the fit and increase the overlap (Law et al., 1996; Letts et al, 1994). The PEO model also discusses temporal adaptation and the

therapists' use of compensatory techniques (Law et al., 1996). The Ecology of Human Performance (EHP) states that person and/or contextual factors affect performance (Dunn, Brown, & McGuigan, 1994). One of the five therapeutic intervention techniques to address performance issues is to adapt contextual or person factors (Dunn et al., 1994).

Occupational Adaptation is an appropriate model for use with ITW as this study postulates that some individuals toe walk due to the need to meet occupational challenges and difficulties adapting. The occupational challenges in idiopathic toe walking are: the desire to meet sensory needs; the need to alert the sensory systems, including proprioception, in order to maintain postural control and successfully ambulate; and the desire to participate in the social environments. Adaptation is essential for successful integration. Adaptive responses and active participation are necessary in order for individuals to work within given environments (Schaaf & Davies, 2010). In activities requiring coordinated movement and integration of the sensory systems, the sensorimotor person system should be dominant (Schkade & Schultz, 1992; Schkade & McClung, 2001).

Sensory Processing

Sensory processing is an area that has been well studied within occupational therapy literature. In humans, sensory processing refers to the "reception of a physical stimulus, transduction of the stimulus into a neural impulse, and perception, or, the conscious experience of sensation" (Ahn, Miller, Milberger, & McIntosh, 2004, p. 287). Sensory processes are necessary for learning, perception, and action (Kandel, Schwartz, & Jessell, 2000). Impairments in processing can occur in one or more of the seven

sensory systems including smell, taste, auditory, touch, olfactory, proprioception, and vestibular. Within the general pediatric population, 5-16% of children have sensory processing difficulties severe enough to interfere with daily functioning and poor or impaired sensory processing may affect as many as 40-88% of children with various disorders (Adrien et al., 1993; Ahn et al., 2004; Ben-Sasson, Carter, & Briggs-Gowan, 2009; Kientz & Dunn, 1997; Talay-Ongan & Wood, 2000).

Proprioception is one sensory area in which individuals may have difficulty processing information. Proprioception was first defined as the awareness of joint movement and place in space (Sherrington, 1906). The definition was later expanded to include kinesthesia and position sense along with information from joint capsules, ligaments, muscles, tendons, and skin (Ayres, 2005). According to Ayers, motor planning and regulation of arousal level are influenced by the proprioceptive system. Miller and Fuller (2006) defined proprioceptive discrimination disorder as "impairment in the ability to feel the amount of sensory input to the joints and muscles" (p. 166). A decrease in proprioceptive awareness is also associated with sensory seeking and low registration along with decreased body awareness. Tiptoeing has been identified as an observation of proprioceptive difficulties (Blanche, Bodison, Chang, & Reinoso, 2012; Blanche & Reinoso, 2008). The literature suggests that toe walking may result from difficulty processing information from the proprioceptive system; therefore, the proprioceptive system should be further investigated.

The sensory systems are the building blocks for many other internal and external processes. Figure 2.1, adapted from Williams and Shellenberger (1996), provides a

hierarchy of the central nervous system. The sensory systems are the base from which sensory motor development, perceptual motor development, and cognition/intellect are built. Without appropriate processing of information from the proprioceptive system, along with the other sensory systems, postural security, motor planning, body scheme, and postural adjustments along with many other characteristics may be affected.

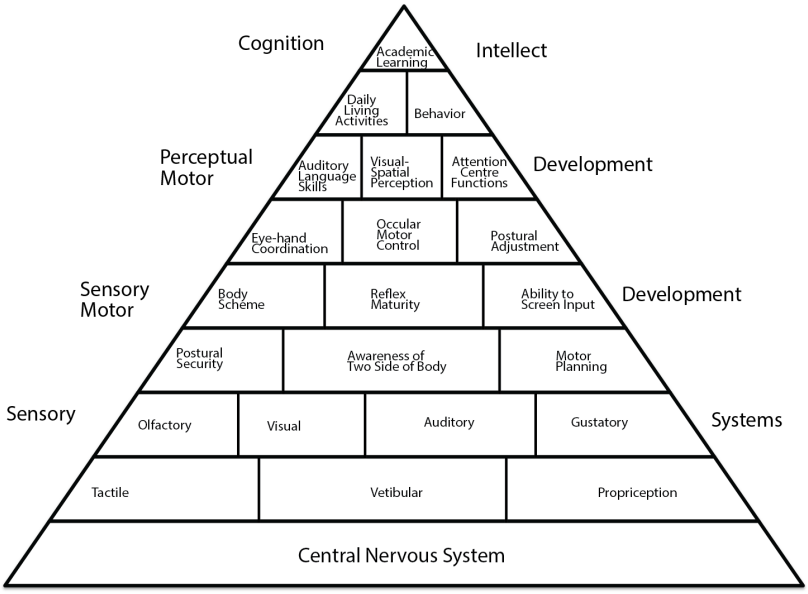

Figure 2.1: Central Nervous System hierarchy

A decrease in proprioceptive awareness, namely postural instability, is also associated with sensory seeking and low registration along with decreased body awareness (Blanche et al., 2012). The relationship between postural instability and ITW has not been fully examined in current literature. Williams et al. (2014) found that children who are idiopathic toe walkers demonstrated the most significant delays in the areas of Upper Extremity Coordination, Bilateral Coordination, and Balance on the Bruinink-Oseretsky Test of Motor Proficiency (BOTMP). Each of these areas on the BOTMP correlate with postural control and stability.

The current practice of addressing ankle and foot tightness for ITW does not address possible underlying sensory issues. In a review of current literature, Williams et al. (2010a) found that while several authors suggested a relationship between sensory processing dysfunction and ITW, there is limited research to support this conclusion. Proprioception, along with the vestibular and tactile systems, provides necessary sensory information for postural control, motor planning, normal body movements and behavioral regulation (Blanche et al., 2012; Blanche & Reinoso, 2008; Williams et al., 2010a). In order to maintain balance, individuals need to perceive when balance is challenged or stability is disrupted. Three systems need to work together to provide information and appropriate responses in order to maintain position: vestibular, proprioceptive, and visual (O'Brien & Williams, 2010).

Neuroscience Related to ITW and Proprioception

There is a strong foundation of neuroscience in ITW especially related to sensory processing, proprioception, and postural control. In order to understand the relationship between ITW and proprioception, it is essential to understand the neuroscience of proprioception. Proprioceptive information travels from proprioceptive receptors, primarily found in joints, muscles, and ligaments, via the dorsal lateral tracts or the spinocerebellar tracts to the somatosensory cortex in the parietal lobe of the cerebral cortex (Riemann & Lephart, 2003). Feedback (corrective responses) and feedforward (anticipatory actions) controls are regulated by proprioception for the preservation of balance (Riemann & Lephart, 2003; Subasi, 2014). Disruption in the proprioceptive system would result in inaccurate feedforward and impaired motor movements, of which

toe walking is an example. Figure 2.2 (Sensory-motor feedback loop [figure], 2011), adapted from AnimatLab, provides an illustration for this process. The sensory and motor systems work together to respond to internal and external forces. Individuals must be able to process information from the proprioceptive systems, along with other sensory systems, and respond with appropriate motor activation and muscle contraction. Environmental influences such as gravity and buoyance are also factors that contribute to this process. When there is a disruption in the processing of proprioception, other components of the loop are also affected and the motor response may be impaired.

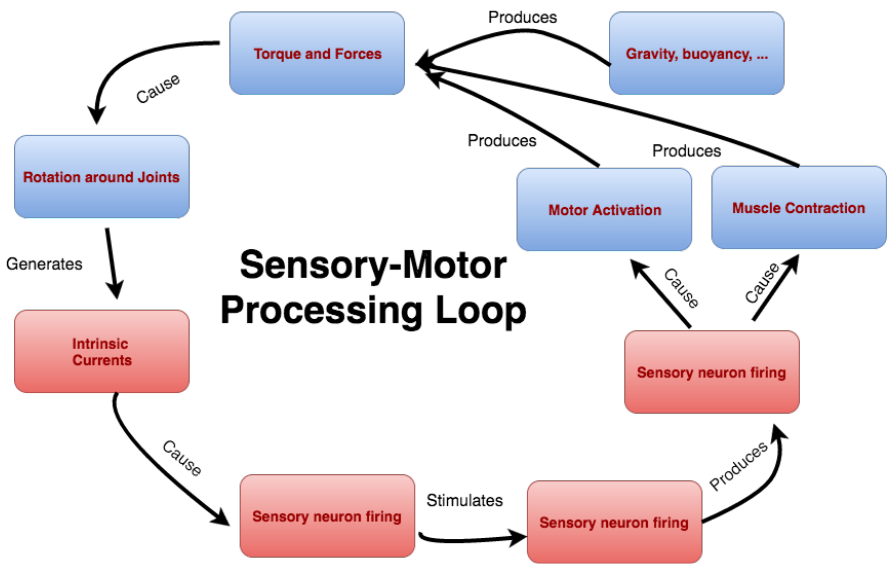

Figure 2.2: Sensory-Motor Processing Loop

Sensory Re-weighting

Sensory re-weighting refers to the ability to process sensory information, weigh the importance of the information, and respond appropriately (Bair, Kiemel, Jeka, & Clark, 2007; Polastri & Barela, 2013). Many recent studies have suggested that there is a relationship between the development of postural control and the use of sensory information in order to respond with correct muscle activation (Barela, Jeka, & Clark, 1999, 2003; Clark & Metcalfe, 2000). A recent non-experimental case-control study utilizing a force plate to determine center of pressure (CoP) under four conditions, for toe walkers versus non-toe walkers found that when toe walkers stood flat-footed, they had more posteriorly positioned CoP compared to controls (Koskovich, Berg-Poppe, Yom, Inglis, & Streleck, 2014). Koskovich et al. (2014) also found greater between-group differences in CoP position under more complex sensory situations, such as on a foam surface with eyes closed, and they reported implications for postural control reeducation and a sensory integration approach in the treatment of ITW. The evidence suggests that one possible neuromechanism of ITW is postural disorder and an impairment in processing information from the proprioceptive system along with vestibular, visual, and/or tactile systems. More research is necessary to demonstrate the possible correlation.

The current research helps to identify ITW as an indicator of proprioceptive difficulties, and subsequently, those who would benefit from occupational therapy to address underlying sensory needs. Children with ITW associated with sensory processing disorders, namely proprioceptive and postural disorders, may have difficulties in other areas of their lives. Toe walking appears to also have long-term consequences including

damage to joints and lifelong gait abnormalities (Hoppestad, 2013). Toe walking also leads to other occupational performance area difficulties in social participation and fulfilling life roles. Occupational therapists, using an OA approach, can help children to adapt and function more fully while reducing their tendency to toe walk.

CHAPTER III

PILOT STUDY

This chapter will describe a pilot study conducted to examine the relationship between proprioception and ITW followed by a description of the proposed study.

To determine the likelihood of difficulties in proprioception, namely postural control contributing to ITW, a pilot study was completed comparing the postural control of idiopathic toe walkers and age-matched peers. The study, entitled "Idiopathic Toe Walking and Postural Instability: Going Beyond the Toes," was approved by TWU's IRB on November 14, 2014. The flyer distributed to parents is included as Appendix A and the agency approval letters are included as Appendix B.

Study Overview

Research Aim

The aim of this study was to determine if a difference exists in the postural control and sensory processing of children who are idiopathic toe walkers and those who are not toe walkers. The results of this study helped determine the need for additional research into the correlation between ITW, postural control, and modulation of sensory systems, namely proprioception and body awareness.

Design and Methods

This exploratory study was a non-randomized case-control design with concurrent control. The study examined the postural control and proprioception of idiopathic toe walkers and age- and gender-matched peers. This design tested the following hypotheses:

1. Children with an idiopathic toe walking gait will demonstrate postural control difficulties as evident by differences in time in the following positions: sustained tall kneeling position with a modified reach test, squatting against a wall, prone extension, and supine flexion compared to non-toe walking cohort.
2. Children with an idiopathic toe walking gait and children with autism who toe walk will have a different response to everyday sensory challenges as evident by scores on the Sensory Profile 2 compared to the non-toe walking cohort.

Participants

Eight children (3 years, 0 months to 12 years, 3 months) with a diagnosis of idiopathic toe walking and eight children (3 years, 0 months to 12 years, 6 months) without idiopathic toe walking were recruited from the community.

Inclusion criterion. Idiopathic Toe Walking (ITW) cohort: Eight children who exhibited bilateral toe walking without a known neurogenic, neuromuscular, or traumatic cause were included in the ITW cohort. The Toe Walking Tool (Williams et al., 2010b) determined if recruited participants met the criterion for inclusion in this cohort. The Toe Walking Tool is included as Appendix C. Control Cohort: Fifteen children without a diagnosis of ITW were included in this cohort. Children were enrolled consecutively and

were age-, gender-, and BMI-matched with children in the experimental cohorts. The Toe Walking Tool (Williams et al., 2010b) determined if recruited participants met inclusionary criterion for this cohort.

Exclusion Criterion. ITW cohort: Children with Toe Walking Tool scores that indicate a neurogenic, neuromuscular, or traumatic cause for toe walking would have been excluded from this cohort. Children with unilateral toe walking, those who are non-toe walkers, children with autism who toe walk, and those with toe walking due to a diagnosis such as cerebral palsy, muscular dystrophy, or scoliosis were excluded from involvement in the study. Control cohort: Children who toe walk as determined by scores on the Toe Walking Tool for any reason, including neurogenic, neuromuscular, traumatic, or idiopathic causes for toe walking would have been excluded from this cohort. Children with a medical or educational diagnosis of autism who do not toe walk would have been excluded from this group as well.

A total of eight toe walkers and eight age-, gender-, and BMI-matched peers were evaluated in the study. See Table 3.1 and Table 3.2 for participant demographic information.

Table 3.1

Ages and Gender of Participants for Pilot Study

Group	Age Range	Mean	n	SD	Gender (Female)
ITW	3:0 – 12:3	7.41	8	2.99	5 (63%)
Control	3:0 – 12:6	7.41	8	2.99	5 (63%)
Total	3:0 – 12:6	7.41	16	2.89	10 (63%)

Table 3.2

Age Ranges for Participants for Pilot Study

Age Range (in years)	ITW	Control	Total
3.0-3.11	1	1	2
4:0-4:11	0	0	0
5:0-5:11	1	1	2
6:0-6:11	2	2	4
7:0-7:11	2	2	4
8:0-8:11	0	0	0
9:0-9:11	0	0	0
10:0-10:11	0	0	0
11:0-11:11	1	1	2
12:0-12:11	1	1	2
Total	8	8	16

Measurements

The Toe Walking Tool (Williams et al., 2010b) was utilized to determine eligibility for the study. This tool has been found to be valid and reliable in identifying children who demonstrate an ITW gait and excluding those who are non-toe walkers and those who toe walk due to a diagnosis (Williams et al., 2010b)

The Sensory Profile 2 (SP 2) (Dunn, 2014) was utilized for children 3 years, 0 months to 14 years, 11 months of age to determine if they have difficulties regulating sensory information from various systems. This tool was standardized from 1993 to 1999 with more than 1,200 children with and without disabilities between the ages of 3:0 and 14:11. The SP 2 is a caregiver report questionnaire. An early version of the assessment, The Sensory Profile, has been used in studies with idiopathic toe walkers (Williams et al., 2014). This revised questionnaire evaluates a child's unique sensory processing patterns

and is completed by caregivers, who are in the strongest position to observe the child's response to sensory interactions which occur throughout the day.

Clinical observation was used to evaluate postural control in four positions: tall kneeling with a modified reach test, squat against a wall, prone extension, and supine flexion. Standing balance and sway has long been used to evaluate postural control (Horak, 1987; Memari et al., 2013; Nolan & Kerrigan, 2004). For the purpose of this study, the aim was to evaluate postural control in children who have ITW gait. Therefore, the positions were chosen in order to: first, decrease the input from the lower extremities (tall kneeling, supine flexion, and prone extension) and second, determine control in a position that requires integration of postural control along with stability (squat position). Squatting is often used in studies to evaluate core muscle activation or postural control (Hamlyn, Behm, & Young, 2007; McCurdy, Kutz, O'Kelley, Langford, & Ernest, 2010; Saeterbakken & Fimland, 2013; Weir et al., 2010; Willardson, Fontana, & Bressel, 2009). Thus, squatting against the wall was an appropriate position to use in this study to evaluate postural control of toe walkers and non-toe walkers. While in the tall kneeling position, the child was asked to complete a modified reach test in order to further evaluate his/her postural control. This assessment has been used and standardized for children ages 3 to 14 while in a standing position (Deshmukh, Ganesan, & Tedla, 2011; Norris, Wilder, & Norton, 2008).

Antigravity or supine flexion is the ability to flex the head, trunk, and extremities against gravity while lying on the back. This position has been associated with somatosensory processing; difficulty maintaining this position, especially the location of

the neck, is associated with somatodyspraxia and has been associated with postural problems. (Blanche, 2010; Fisher, Murray, & Bundy, 1991). Antigravity or prone extension is the ability to simultaneously lift the head, arms, upper trunk, and extended legs up against gravity in a prone-lying position. Difficulty maintaining this tonic postural extension against gravity has been associated with posturalocular movement disorder (Blanche, 2010; Fisher et al., 1991).

Procedures

Following Institutional Review Board approval and parental consent, each child was assessed individually. The study evaluation took place at a pediatric therapy clinic or at the home of the family. The primary investigator (PI) discussed the purpose of the evaluation, procedures, and asked if they had any questions about the process at the onset of the evaluation. Parent(s) and children were encouraged to ask questions throughout the session. The PI moved the family to a treatment area in the clinic or to a table at the family's home in order to complete the Toe Walking Tool questions 1-19 and 25-26 seeking replies from the parent(s). The child was then asked to moved to a small treatment room in the clinic or, if at the family's home, to a couch or bed for evaluation of questions 20-24. Based on the results of the Toe Walking Tool, children were enrolled in the following group: *ITW cohort*, if the tool revealed toe walking without underlying diagnosis or *control cohort,* if the tool revealed no toe walking. If the Toe Walking Tool had revealed that the child was not eligible for the study, based on inclusion and exclusion criterion listed previously, parent(s) and child would have been thanked for their time and child would have been allowed to pick a sticker or pencil from a bucket.

No children were excluded from this study. If the child met the eligibility requirement, the parent(s) then completed a demographic page and the SP 2 following which the PI began the evaluation procedures with the child.

The PI set up the treatment room or designated area in the home for the assessment. Once the PI established rapport with the child, he/she was asked to tall kneel against a predetermined wall with right shoulder against the wall following demonstration by the PI. The child was asked to keep knees on two pieces of tape which were placed shoulder-width apart with lateral aspect of right arm parallel to a nearby wall. A meter-stick was taped to the wall at the level of the child's acromion. He/she was asked to reach forward as far as possible without moving knees or losing balance. The modified functional reach test was described in the following way: "Make a fist. Raise your (right) arm this high (shoulder height). Reach forward as far as you can, but don't fall or take a step." Each child was allowed to perform two practice trials, which were not recorded. Demonstrations and verbal instructions were repeated in the same format for each child. To measure functional reach distance, an initial measure was taken with the child's arm raised horizontally (approximately 90°of shoulder flexion) using the placement of the third metacarpal along the meter-stick. A second measure was taken after reaching; again using the location of the third metacarpal along the meter-stick.

After the brief break period of two minutes, the child was asked to squat against a predetermined wall (Norris et al., 2008). The PI demonstrated the position by placing back against the wall and walking feet outward until a squatting position could be assumed against the wall with ankles, knees, and hips at 90-degree angles, and arms

hanging at side against the wall. The PI had two small feet, cut out of shelf liner, placed on the floor so that the child was in the proper position when he/she squatted against the wall. The squatting test was described in the following way: "Look at the two feet taped to the floor. Put your feet on the pictures and your back against the wall. Make sure to keep your back against the wall and your hands touching the wall." The PI then helped the child assume a proper position with ankles, knees, and hips at 90-degree angles and arms hanging at the child's side and touching the wall. The PI made note of the child's heel and foot position when child assumed the position without timing but then repositioned his/her ankle and foot as necessary to make sure that they were in appropriate alignment with toes directly under knees and not turned out or in. After repositioning as necessary, PI said, "That looks good, now hold that position as long as you can with your back against the wall and your hands touching the wall." After giving the last direction, the PI began timing with a stopwatch and gave up to two verbal cues for positioning. Timing was continued until the child fell so that hips/knees were no longer in 90 degrees, child was given two verbal cues for positioning and needed an additional cue, or child stepped out of position.

The child was asked to sit on the floor with the PI to take a brief break of two minutes before assuming the next position, supine flexion. The PI demonstrated the position by assuming a supine position on the floor and simultaneously bringing knees toward chest, placing hands just below knees, and flexing neck to bring head towards knees. Supine flexion was described in the following way, "Bring your knees and head up and see if you can get them to touch. Put your hands right here (pointing to area just

below knees) and hold as long as you can. When you can't hold it any longer, you can pop out like popcorn." PI began timing after child assumed position and all instructions had been given, and continued timing until child's head or lower extremities returned to the floor.

The child was given a brief break of two minutes to sit or lie on the ground prior to assuming the final position, prone extension. The PI demonstrated the position by assuming a prone position on the floor with bilateral arms raised above head and extending lower extremities, trunk, and neck in order to raise thighs and upper body off the ground. Prone extension was described in the following way, "You get to fly like superman (super girl). Bring your hands up over your head and raise your legs, head, and arms up off of the ground. Keep your arms, legs, and head up as long as you can so you can fly over all of the buildings." PI began timing after child assumed position and all instructions had been given and continued timing until child's knees, arms, and/or head returned to the floor.

At the completion of the assessment, the PI asked the parent(s) and child if they had any questions or concerns. The PI explained that once the SP 2 was scored, the parents would receive a copy of the assessment along with the child's scores in the various positions, if the parent(s) provided an address. The child was allowed to pick out a sticker or pencil from a bucket at the conclusion of the session.

Data Collection and Analysis

Data were collected during the evaluation. Data included: demographics (provided by parent(s) at onset of session), SP 2 (completed by parent(s) during session),

and time and body position during squat tests, modified reach test while in tall kneeling position, supine flexion, and prone extension positions. The PI scored the SP 2 and monitored time and body position for the tall kneel, squat tests, supine flexion, and prone extension. The data collected during the study were analyzed using SPSS Version 22 (IBM Corp, 2013). A Mann-Whitney *U*-Test was used to analyze the date. This is "one of the more powerful nonparametric procedures, designed to test the null hypothesis that two independent samples come from the same population" (Portney & Watkins, 2000, p. 475). The results of this test are found in Table 3.3.

Table 3.3

Results of Mann-Whitney U-Test for Clinical Observation Positions

	Group						
	ITW			Control			
	Mean Ranking	SD	n	Mean Ranking	SD	n	p
Reach Test (in inches)	7.56	4.01	8	10.91	3.39	8	.113
Wall Squat (in seconds)	22.62	10.77	8	55.38	33.33	8	.015*
Supine Flexion (in seconds)	15.50	9.59	8	52.13	50.99	8	.073
Prone Extension (in seconds)	31	24.33	8	55.88	40.28	8	.207

* $p < .05$

Results

The children were evaluated in four different positions related to postural control: a modified reach test (in which the children tall kneeled and reached forward), squatting against the wall, supine flexion, and prone extension. There were significant differences

between the toe walkers and non-toe walkers in one clinical observation position, wall squat (p=.015), and supine flexion approached significance (p=.073). See Tables 3.4 through 3.7 for brief descriptions of the clinical observation results. Table 3.4 shows the tall kneel reach (modified reach test) by age. Table 3.5 shows the wall squat by age. Table 3.6 shows supine flexion by age and Table 3.7 shows prone extension by age. For full detailed results by age and test, see Appendices D and E.

Table 3.4

Tall Kneel Reach (Modified Reach Test) by Age (in cm)

Age/Gender	ITWs (cm)	Non-Toe Walkers (cm)
3F	5.08	17.78
5F	12.7	15.875
6M	12.7	27.94
6F	17.78	25.4
7M	17.78	27.94
7F	20.32	27.94
11M	30.48	40.64
12F	36.83	38.1
Total	153.67	221.62
Average	19.21 cm	27.70 cm

Table 3.5

Wall Squat by Age (in seconds)

Age/Gender	ITWs	Non-Toe Walkers
3F	4	5
5F	21	30
6M	28	35
7M	9	62
6F	30	98
7F	26	50
11M	35	60
12F	28	103
Total	181	443
Average	22.63 seconds	55.38 seconds

Table 3.6

Supine Flexion by Age (in seconds)

Age/Gender	ITWs	Non-Toe Walkers
3F	3	6
5F	6	9
6M	6	19
6F	16	32
7M	20	70
7F	23	58
11M	20	60
12F	30	163
Total	124	417
Average	15.5 seconds	52.13 seconds

Table 3.7

Prone Extension by Age (in seconds)

Age/Gender	ITWs	Non-Toe Walkers
3F	0	3
5F	32	20
6M	13	26
6F	18	45
7M	30	67
7F	22	98
11M	60	67
12F	73	121
Total	248	447
Average	31 seconds	55.88 seconds

The children were also evaluated using the SP 2 (Dunn, 2014). This is a caregiver report questionnaire and an early version of the assessment, The Sensory Profile, has been used in studies with idiopathic toe walkers (Williams et al., 2014). This revised questionnaire evaluates a child's unique sensory processing patterns and is completed by caregivers. The data were analyzed using SPSS Version 22 (IBM Corp, 2013). Independent sample *t* tests for equality of means were used in order to determine whether

differences between the Sensory Profiles completed by parents of idiopathic toe walkers and Sensory Profiles completed by parents of age- and gender-matched peers who do not exhibit this gait pattern were significant. There were no significant differences between toe walkers and non-toe walkers for this tool.

Discussion and Conclusion

This study revealed that there were significant differences between toe walkers and non-toe walkers in one of the test positions (wall squats) and another approached significance (supine flexion). As a whole, the toe walkers had more difficulty sustaining each of the positions and did not reach as far as non-toe walkers with the most noted difficulty found in supine flexion and wall squat. The toe walkers demonstrated abilities most similar to non-toe walking peers in the area of prone extension. The difficulties in supine flexion and relative strength in prone extension may be due to increased use of extensor muscles when toe walking.

There was no significant difference between toe walkers and non-toe walkers in this study on the SP 2. Lack of significant results from this tool may be due to small cohorts and/or low number of questions related to proprioception on the SP 2. The Sensory Processing Measure-Home Form (Parham & Ecker, 2007) contains more questions related to this area (E. Blanche, personal communication, November 8, 2014; Blanche et al., 2012).

The results for this study indicate that difficulties in postural control and proprioception may be a factor in ITW; however, the small sample size makes it difficult

to generalize the results. This study suggests that more research is needed to investigate the connection between proprioception and ITW.

CHAPTER IV

DISSERTATION STUDY OVERVIEW AND PROCEDURES

This chapter presents the study conducted to broaden the scope when investigating ITW and sensory processing. The pilot study included four postural control positions and the SP 2. Although the pilot study had a small cohort of idiopathic toe walkers (n=8) and age-, gender-, and BMI-matched peers (n=8), it indicated that additional research is needed to investigate the correlation between toe walking and proprioception. In this dissertation study, one clinical observation item was changed, the Sensory Profile was deleted, and the Sensory Processing Measure-Home Form and Sensory Processing Measure-Preschool Home Form were added.

Study Overview

Research Aim

The aim of this study was to determine if there is a difference in the postural control and sensory processing of children who are idiopathic toe walkers and those who are not toe walkers. The results of this study will help to expand knowledge regarding the correlation between ITW, postural control, and modulation of sensory systems, namely proprioception and body awareness.

Design and Methods

This exploratory study was a non-randomized case-control design with concurrent control. The study examined the postural control and proprioception of

idiopathic toe walkers and age- and gender-matched non-toe walking peers. This design tested the following hypotheses:

1. Children with an idiopathic toe-walking gait will demonstrate postural control differences as evident by differences in time in the following positions: squatting against a wall, prone extension, and supine flexion compared to non-toe walking cohort.
2. Children with an idiopathic toe-walking gait will demonstrate postural control differences as evident by differences in ability to maintain arm position and inability to disassociate arms from trunk in the following position: Schilder's arm extension test compared to non-toe walking cohort.
3. Children with an idiopathic toe-walking gait will have a different response to everyday sensory challenges as evident by parental responses to body awareness questions from the SPM-Home Form compared to the non-toe walking cohort.

Participants

Fifteen children 4 years, 0 months to 13 years, 2 months with a diagnosis of idiopathic toe walking and fifteen children 3 years, 10 months to 13 years, 5 months without idiopathic toe walking were recruited from the community.

Inclusion criterion. Idiopathic Toe Walking (ITW) cohort: Fifteen children who exhibited bilateral toe walking without a known neurogenic, neuromuscular, or traumatic cause were included in the ITW cohort. The Toe Walking Tool (Williams et al., 2010b) determined if recruited participants met criterion for inclusion in this cohort. The Toe Walking Tool is included as Appendix C. Control Cohort: Fifteen children without a

diagnosis of ITW were included in this cohort. Children were enrolled consecutively and were age- and gender-matched with children in the experimental cohort. The Toe Walking Tool (Williams et al., 2010b) determined if recruited participants met criterion for inclusion in this cohort.

Exclusion criterion. ITW cohort: Children with Toe Walking Tool scores that indicate a neurogenic, neuromuscular, or traumatic cause for toe walking, based on the Toe Walking Tool, were excluded from this cohort. One child who was evaluated with the Toe Walking Tool was excluded for this reason. Children with unilateral toe walking, those who are non-toe walkers, children with autism who toe walk, and those with toe walking due to diagnoses such as cerebral palsy, muscular dystrophy, or scoliosis were excluded from involvement in the study. Control cohort: Children who toe walk as determined by scores on the Toe Walking Tool for any reason, including neurogenic, neuromuscular, traumatic, or idiopathic causes for toe walking were excluded from this cohort. Children with a medical or educational diagnosis of autism, who did not toe walk, would have been excluded from this group as well. One child evaluated for participation in the control cohort was excluded due to results of the Toe Walking Tool.

Exclusionary Tool

The Toe Walking Tool. The Toe Walking Tool (Williams et al., 2010b) is a validated exclusionary tool and was utilized to determine eligibility for the study. This tool has been found to be valid, via a Delphi panel process, and reliable in identifying children who demonstrate an ITW gait and excluding those who are non-toe walkers and those who toe walk due to diagnosis (Williams et al., 2010b). The Toe Walking Tool was

utilized to ensure that only healthy children who toe walked without a known diagnosis were included in the study. It was also used to ensure that participants in the control group did not toe walk or have other risk factors that would eliminate them as part of this group. The tool includes questions related to "birth history, lower limb musculoskeletal, and neurological examination and a developmental screen (Brigance Screen)" (Williams et al., 2014).

Measurement Tools

Sensory Processing Measure. The Sensory Processing Measure-Home Form (SPM-Home Form) and the Sensory Processing Measure-Preschool Home Form (SPM-P Home Form) were utilized to assess possible difficulties processing proprioceptive information (Parham & Ecker, 2007). These tools are included as Appendices F and G. The SPM-Home Form and SPM-P Home Form are rating scales that assess sensory processing issues, praxis, and social participation and are based on the sensory integration theory (Parham & Ecker, 2007; Ayers, 2005). The SPM-P Home evaluates preschool children ages 2-5 and the SPM-Home evaluates school-aged children. These questionnaires evaluate a child's unique sensory processing patterns and are completed by caregivers, who are in the strongest position to observe the child's response to sensory interactions that occur throughout the day. There are 10 questions on the SPM-Home Form that relate to body awareness and proprioception; these were used in order to establish content validity for the Comprehensive Observations of Proprioception (COP) (Blanche et al., 2012). The 10 questions related to body awareness are included in the table below; however, the entire SPM-Home and SPM-P Home Forms were utilized for

this study in order to evaluate any difference in sensory processing of children who toe walk when compared to children who do not exhibit this gait pattern. The SPM-Home Form has an internal consistency that was established with Cronbach's alpha ranging from .77 to .95 (Parham & Ecker, 2007). This tool also has excellent test-retest reliability ranging from .94 to .98 (Parham & Ecker, 2007).

Table 4

SMP-Home Body Awareness Questions

Item No.	Does Your Child
46	Grasp objects (such as a pencil or spoon) so tightly that it is difficult to use the object?
47	Seem driven to seek activities such as pushing, pulling, dragging, lifting, and jumping?
48	Seem unsure how far to raise or lower the body during movement such as sitting down or stepping over an object?
49	Grasp objects (such as a pencil or spoon) so loosely that it is difficult to use the object?
50	Seem to exert too much pressure for the task, such as walking heavily, slamming doors, or pressing too hard when using pencils or crayons?
51	Jump a lot?
52	Tend to pet animals with too much force?
53	Bump or push other children?
54	Chew on toys, clothes, or other objects more than other children do?
55	Break things from pressing or pushing too hard on them?

Clinical observations. Clinical observation was used to evaluate postural control in four positions: squat against a wall, prone extension, supine flexion, and Schilder's arm extension test. As in the pilot study, the aim of this study was to evaluate postural control in children who exhibit an ITW gait. Therefore, the positions were chosen in order to: first, decrease the input from the lower extremities (supine flexion and prone extension) and second, determine control in a position that requires integration of

postural control along with stability (squat position and Schilder's arm extension test). Squatting is often used in studies to evaluate core muscle activation or postural control (Hamlyn et al., 2007; McCurdy et al., 2010; Saeterbakken & Fimland, 2013; Weir et al., 2010; Willardson et al., 2009). Therefore, squatting against the wall is an appropriate position to use in this study to evaluate postural control of pediatric toe walkers and non-toe walkers.

Schilder's arm extension test is used to evaluate proprioception in children (Blanche et al., 2012). In order to perform the Schilder's arm extension test, the child stands with arms extended at 90 degrees and eyes closed. Inability to disassociate the trunk from the head (i.e. moving arms in the direction of the head turn) and/or maintain extended arm position (i.e. drops arms below shoulder height with eyes closed and/or head turn) is related to poor proprioceptive processing (Blanche et al., 2012; Schilder, 1931). Most children five years old or older can keep their arms up, with eyes closed, while head is passively rotated from side to side (Blanche, 2010). Children as young as three years of age may also demonstrate this ability.

Antigravity, or supine flexion, is the ability to flex the head, trunk, and extremities against gravity while lying on the back. Supine flexion has been associated with somatosensory processing; difficulty maintaining this position, especially the neck location, is linked with somatodyspraxia which, has been associated with postural problems (Blanche, 2010). Antigravity, or prone extension, is the ability to simultaneously lift the head, arms, upper trunk, and extend legs up against gravity in a prone-lying position. Difficulty maintaining tonic postural extension against gravity has

been associated with posturalocular movement disorder (Blanche, 2010; Ayers, 2005). Schilder's arm extension test, supine flexion, and prone extension are included as proprioceptive components in Observations Based on Sensory Integration Theory (Blanche, 2010). Schilder's arm extension test was evaluated using two criterion: was the child able to maintain arm position without dropping more than five degrees and was the child able to keep arms at midline while head was turned? The child received a score of 2 if he/she maintained the arm position or a score of 1 if his/her arms dropped more than five degrees. The child received a score of 3 if his/her arms remained at midline when his/her head was turned bilateral directions, a score of 2 if his/her arms moved in a single direction with head turn, or a score of 1 if his/her arms moved with head turn in bilateral directions.

Procedures

Following Institutional Review Board approval for modifications to current IRB-approved study, and following parental consent, each child was assessed individually. The study evaluations took place at a pediatric therapy clinic or at the home of the family. At the onset of the evaluation, the PI discussed the purpose of the evaluation, procedures, and asked if they had any questions about the process. Parent(s) and children were encouraged to ask questions throughout the session. See Appendix H for Informed Consent Form, which was given to parent(s) at the onset of the evaluation. Children were asked to give verbal assent prior to beginning assessment. The PI moved the child and family to a quiet area in the clinic or in family's home in order to complete the Toe Walking Tool questions 1-19 and 25-26 by asking the parent(s) to verbally reply to

questions. The child was then asked to move to a small treatment room in the clinic or, if at the family's home, to a couch for evaluation of questions 20-24. Based on the results of the Toe Walking Tool, children were enrolled in the following group: ITW cohort, if the tool revealed toe walking without underlying diagnosis; or control cohort, if the tool revealed no toe walking. If the Toe Walking Tool revealed that the child was not eligible for the study based on inclusion and exclusion criterion listed previously, parent(s) and child were thanked for their time and child was allowed to pick a sticker or pencil from a bucket and leave the clinic. Two children were excluded from the study, one from the toe walking group and one from the control group, for this reason. If the child met the eligibility requirement, the PI asked parent(s) questions to complete a demographic page which was part of the observation sheet, see Appendix I, and parent(s) answered questions from SPM-Home Form or SPM-P Home Form, and the PI began the evaluation procedures with the child.

The PI set up the treatment room or designated area in the home for the assessment. Once the PI established rapport with the child, he/she was asked to stand in the middle of the room with back towards the PI. Schilder's arm extension test was described in the following way: "Raise your arms out in front of you just like this (PI demonstrated raising arms to shoulder height). In just a minute, I'm going to ask you to close your eyes and I'm going to turn your head to each side. Make sure to keep your arms straight out in front of you." Demonstrations and verbal instructions were repeated in the same format for each child. The PI noted child's arm position and disassociation of trunk and body on the observation sheet.

After a brief break period of two minutes, the child was asked to squat against a predetermined wall. The PI demonstrated the position by placing back against the wall and walking feet outward until a squatting position could be assumed against the wall with ankles, knees, and hips at 90-degree angles and arms hanging at side against the wall. The PI had two small feet, cut out of shelf liner, placed on the floor so that the child was in the proper position when he/she squatted against the wall. The squatting test was described in the following way: "Look at the two feet taped to the floor. Put your feet on the pictures and your back against the wall. Make sure to keep your back against the wall and your hands touching the wall." The PI then helped the child assume a proper position with ankles, knees, and hips at 90-degree angles and arms hanging at the child's side, touching the wall. The PI made note of the child's heel and foot position when child assumed the position without timing, then repositioned his/her ankle and foot as necessary to make sure that they were in appropriate alignment with toes directly under knees and not turned out or in. After repositioning as necessary, PI said, "That looks good. Now hold that position as long as you can with your back against the wall and your hands touching the wall." The PI began timing with a stopwatch after giving the last direction and gave up to two verbal cues for positioning. Timing continued until the child fell so that hips/knees were no longer at 90 degrees, child was given two verbal cues for positioning and needed an additional cue, child asked to stop, or child stepped out of position.

The child was asked to sit on the floor with the PI to take a brief break of two minutes before assuming the next position, supine flexion. The PI demonstrated the

position by assuming a supine position on the floor and simultaneously bringing knees toward chest, placing hands across the chest and flexing neck to bring head towards knees. Supine flexion was described in the following way, "Bring your knees and head up and see if you can get them to touch. Cross your hands across your chest (PI gave child visual and physical cues if necessary) and hold this position as long as you can. When you can't hold it any longer, you can pop out like popcorn." PI began timing after child assumed position and all instructions had been given and continued timing until child's head or lower extremities returned to the floor. Children who were five years old and younger were unable to hold this position so the test position was modified in the following way: Children ages 3 years, 0 months to 5 years, 12 months were asked to bring their knees and head up and place hands on shins. PI demonstrated this position prior to having each child attempt it. Supine flexion was described in the following way for this group, "Bring your knees and head up and see if you can get them to touch. Place your hands here on your legs (PI gave child visual and physical cues if necessary) and hold this position as long as you can. When you can't hold it any longer, you can pop out like popcorn." PI began timing after child assumed position and all instructions had been given and continued timing until child's head or lower extremities returned to the floor.

Each child was given a brief break of two minutes to sit or lie on the ground prior to assuming the final position, prone extension. The PI demonstrated the position by assuming a prone position on the floor, with bilateral arms raised above head, and extending lower extremities, trunk, and neck in order to raise thighs and upper body off the ground. Prone extension was described in the following way, "You get to fly like

superman (super girl). Bring your hands up over your head and raise your legs, head, and arms up off of the ground. Keep your arms, legs, and head up as long as you can so you can fly over all of the buildings." The PI began timing after the child assumed position and all instructions had been given and continued timing until child's knees, arms, and/or head returned to the floor. The PI gave up to one verbal cue for positioning before ending test position if child was unable to assume proper position.

The PI evaluated each of the participants on the wall squat, supine flexion, and prone extension positions using a stopwatch, in seconds, to monitor how long each child was able to maintain each position. The PI also observed body position, ability to get in desired position, verbal or physical cues necessary to get into and maintain position, and stabilization strategies that the child utilized to maintain the position. These were noted on the observation sheet, see Appendix I.

At the completion of the assessment, the PI asked the parent(s) and child if they had any questions or concerns. The PI explained that the parents would receive a copy of the assessment along with the child's scores in the various positions if they included an email or physical address on the consent form. The child was allowed to pick out a sticker or pencil from a bucket at the conclusion of the session.

Data collection and analysis. Data were collected during the evaluation. Data included: demographics (provided by parent(s) at onset of session), questionnaire completed by parent(s) including the SPM-Home or SPM-P Home Form, and time and/or body position during squat test, Schilder's arm extension test, supine flexion, and prone extension positions. SPSS Version 22 (IBM Corp, 2013) was utilized to analyze all of

the data. Independent sample *t* tests were used to analyze possible differences in clinical observations positions between toe walkers and non-toe walkers to determine the relationship between toe walking, postural control, and sensory processing assessments. Appendix J provides the study results by participant. This will be discussed in length in Chapter V.

Ethical Issues

Ethical considerations are important in all studies involving human subjects. This is especially critical in studies involving children. Precautions were taken to ensure the safety of all children during structured and unstructured components of the evaluation. Parent(s) and/or children may have been uncomfortable with procedures of evaluation. Informed consent was obtained from parents and verbal assent was obtained from each child prior to initiating evaluation. They were informed that either the parent(s) or child could ask for a break at any time during the evaluation or they could ask to stop the evaluation at any point. No child was injured in any way during the study and no child asked to take an additional break or asked to stop the evaluation.

Identifiable Data Protection

The study collected the following information: initials, gender, and age in years and months format. Contact information such as mailing address and email address was only recorded if the family requested a copy of the results of the study. Initials, gender, and age were recorded on demographic section of Appendix I. The PI stored all study data in a locked cabinet in her office. The cabinet is located at AbleKids Pediatric Therapy, 2524

Glenn Avenue, Sioux City, Iowa. All study data will be destroyed within five years of completion of the study.

Benefits

Participants and parents received increased knowledge about ITW and proprioception. Participants contributed to the body of knowledge in the treatment of ITW.

CHAPTER V

DATA ANALYSIS AND RESULTS

Chapters I and II provided background information regarding idiopathic toe walking, sensory processing, and proprioception/postural control; Chapter III examined a pilot study conducted in this area; and Chapter IV looked at the procedures involved in this dissertation study. This chapter will provide details of the data analysis and results of the study.

Data Analysis

The data that were collected during the study were analyzed using SPSS Version 22 (IBM Corp, 2013). Independent sample *t* tests for equality of means were used in order to determine whether differences between idiopathic toe walkers and age- and gender-matched peers, who do not exhibit this gait pattern, were significant. The purposes of the study were to 1) determine if children who exhibit an ITW gait pattern exhibit differences in four positions when compared to non-toe walking peers, and 2) determine if there is a difference in response to everyday sensory challenges as reported by parents using the Sensory Processing Measure Home Form (SPM-Home) or Sensory Processing Measure-Preschool Home Form (SPM-P Home). According to Portney and Watkins (2000), "The independent or unpaired t-test is used when two independent groups of subjects are compared" (p. 416). Therefore, an independent sample *t* test was

an appropriate tool to use to analyze the data. An alpha level of .05 was set for each analysis.

Results

Fifteen idiopathic toe walkers and fifteen non-toe walkers participated in the study. The participants ranged in age from 3 years, 10 months to 13 years, 2 months. Tables 5.1, 5.2, and 5.3 provide demographic information for the participants including age ranges and gender. See Appendix J for detailed study results by participant. Table 5.4 provides the results of the independent *t*-test completed for the four clinical observation positions.

Table 5.1

Demographics for Children Who Exhibit ITW and Control Group

Demographic	ITW (n = 15) n (%)	Control (n = 15) n (%)
Gender		
Male	6 (40.0)	6 (40.0)
Female	9 (60.0)	9 (40.0)
Ethnicity		
African-American	0 (0)	1 (6.7)
Caucasian	13 (86.7)	12 (80.0)
Hispanic/Latino	2 (13.3)	1 (6.7)
Unknown	0 (0)	1 (6.7)
Services received		
Occupational Therapy	2 (13.3)	0 (0)
Physical Therapy	1 (6.7)	0 (0)
Speech-language	1 (6.7)	0 (0)

Table 5.2

Ages and Gender of Participants

Group	Age Range	Mean	n	SD	Gender F (%)
ITW	4:0 – 13:2	7.25	15	2.60	9 (60%)
Control	3:10 – 13:5	7.20	15	2.75	9 (60%)
Total	3:10 – 13:5	7.23	30	2.64	18 (60%)

Table 5.3

Age Ranges for Participants

Age Range (in years)	ITW (n=15)	Control (n=15)	Total (n=30)
3.0-3.11	0	1	1
4:0-4:11	3	2	5
5:0-5:11	2	2	4
6:0-6:11	1	1	2
7:0-7:11	4	5	9
8:0-8:11	3	2	5
9:0-9:11	0	0	0
10:0-10:11	0	0	0
11:0-11:11	0	0	0
12:0-12:11	1	1	2
13:0-13:11	1	1	2
Total	15	15	30

Table 5.4

Results of t-test and Descriptive Statistics for Clinical Observation Positions

	Group					
	ITW (n=15)		Control (n=15)			
	M	SD	M	SD	t	p
Schilder's Arm Position	1.53	.52	1.87	.35	-2.066	.049*
Schilder's Disassociation	1.67	.90	2.33	.98	-1.945	.062
Wall Squat (in seconds)	30.33	18.31	53.47	20.59	-3.252	.003**
Supine Flexion (in seconds)	25.8	15.09	53.6	41.77	-2.424	.026*
Prone Extension (in seconds)	37	21.54	62.93	34.32	-2.479	.021*

* $p < .05$, **$p < .01$.

The results of Schilder's arm extension test were separated into two categories for analysis. First, participants were observed based on their ability to maintain a position of arms extended at shoulder height while they closed their eyes and PI passively moved their heads from center to left and center to right. The PI noted whether each child was able to maintain the extended arm position or dropped less than five degrees or if the participant's arms fell five degrees or more. In order to analyze the data using an independent sample *t* test, the same scoring system was used for the toe walking and control groups. The PI and statistician gave each participant a score of 2 if the child was able to maintain the position and a score of 1 if the child's arm fell five degrees or more. The toe-walking group (n=15) had a mean of 1.53 with a standard deviation of 0.52. The control group (n=15) had a mean score of 1.87 with a standard deviation of 0.35. Next,

the PI observed each child's ability to disassociate his/her head from trunk. If the child was able to maintain arm position without moving his/her arms in the direction of the head turn, the child was given a score of 3. If the child's arms moved toward a single direction, he/she was given a score of 2. If the child turned toward both directions when his/her head was turned, he/she was given a score of 1. The same scoring system was used for the toe walking and control groups. The toe-walking group (n=15) had a mean score of 1.67 and standard deviation of 0.90 and the control group (n=15) had a mean score of 2.33 and a standard deviation of 0.99. The arm position (p=.049) was significant while the disassociation (p=.062) approached significance, as alpha was set at <.05, indicating that toe walkers were more likely to have difficulty maintaining arm position during the Schilder's arm extension test.

Eight-four percent of 5-year-olds are able to maintain their arm position with their eyes closed and head passively turned (Dunn, 1981). As this study included toe walkers (n=3) and non-toe walkers (n=3) under the age of five, the PI ran the analysis without this population included. Table 5.4 provides a description of the results of this analysis. Under these conditions, both arm position (p=.039) and disassociation (p=.027) were significant with alpha set at <.05.

Table 5.5

Results of t-test for Schilder's Arm Extension Test for Children 5 years and Older

	Group							
	ITW			Control				
	M	SD	n	M	SD	n	t	p
Schilder's Arm Position	1.67	.49	12	2	0	12	-2.345	.039*
Schilder's Disassociation	1.83	.94	12	2.67	.78	12	-2.69	.027*

* $p < .05$.

The time, in seconds, for wall squat, supine flexion, and prone extension was compared for the toe walking group and the control group. Wall squat (p=.003) was highly significant, while supine flexion (p=.022) and prone extension (p=.017) were significant with alpha set at <.05. The mean time idiopathic toe walkers were able to maintain the wall squat position was 30.33 seconds with a standard deviation of 18.31 and the control group had a mean time of 53.47 seconds with a standard deviation of 20.60. The mean time idiopathic toe walkers were able to maintain the supine flexion position was 25.80 seconds with a standard deviation of 15.09 and the control group had a mean time of 54.27 seconds with a standard deviation of 41.21. The mean time idiopathic toe walkers were able to maintain the prone extension position was 37.00 seconds with a standard deviation of 21.54 and the control group had a mean time of 63.47 seconds with a standard deviation of 33.58. This indicates that idiopathic toe walkers have more difficulty sustaining positions that require postural control than the control group.

Parent(s) answered the questions on the SPM-Home Form or SPM-P Home Form and the PI used the Profile Sheet provided with the measure to interpret scores. The interpretive range for the tool for each subtest included: typical (T score of 40-59), some problems (T score of 60-69), and definite dysfunction (T score of 70-80). The PI then used each child's T score to determine if the child fell in the typical, some problems, or definite dysfunction range for each subtest. The PI and statistician coded each range for analysis: typical (3), some problems (2), and definite dysfunction (1) for each subtest. Table 5.6 provides the mean score and standard deviations for each subtest. Table 5.7 describes the findings for the SPM-Home Form and SPM-P Home Form.

Table 5.6

Mean Scores for Sensory Processing Measure Subtests

Subtest	Group	N	Mean	SD
Social	Toe Walking	15	2.87	.35
	Control	15	2.80	.41
Vision	Toe Walking	15	2.80	.41
	Control	15	2.80	.41
Hearing	Toe Walking	15	2.67	.49
	Control	15	2.73	.59
Touch	Toe Walking	15	2.53	.64
	Control	15	2.87	.35
Body Awareness	Toe Walking	15	2.53	.74
	Control	15	2.67	.48
Balance and Motion	Toe Walking	15	2.53	.64
	Control	15	2.80	.41
Planning and Ideas	Toe Walking	15	2.6	.74
	Control	15	2.93	.26
Total	Toe Walking	15	2.53	.64
	Control	15	2.73	.46

Table 5.7

Results of t-test for Sensory Processing Measure

Subtest	t	p
Social	.475	.638
Vision	0.000	1.00
Hearing	-.336	.739
Touch	-1.570	.13
Body Awareness	-.642	.526
Balance and Motion	-1.355	.188
Planning and Ideas	-1.654	.116
Total	-.984	.333

* $p < .05$

The analysis of the SPM-Home Form and SPM-P Home Form did not indicate significant differences between idiopathic toe walkers and the control group in any of the sensory areas including body awareness. This could be due to a number of factors, which will be discussed in the upcoming chapter.

CHAPTER VI

DISCUSSION AND CONCLUSION

Discussion

This study found significant differences between idiopathic toe walkers and non-toe walkers when in three of four positions which require engagement of the proprioceptive system and postural control: wall squat (p=.003), supine flexion (p=.026) and prone extension (p=.021). This supports the first hypothesis: Child with an idiopathic toe walking gait pattern will demonstrate postural control difficulties as evident by decreased time in the following positions: squatting against a wall, prone extension, and supine flexion compared to non-toe walking cohort. The differences between ITW participants and non-toe walking controls for all of the clinical observation positions were statistically significant with wall squat highly significant. As these positions are related to postural control and proprioception, this indicates that difficulties with processing information from the proprioceptive systems may be an issue for some toe walkers.

For the fourth position, Schilder's arm extension test, there were significant differences in the ability of toe walkers to maintain extended arm position (p=.049) and ability to disassociate head from trunk approached significance (p=.062). According to Blanche (2010), children five years and older should be able to disassociate head from trunk during Schilder's arm extension test. This study included toe walkers (n=3) and

non-toe walkers (n=3) between the ages of 3 years, 11months and 4 years, 5 months. This age group of children is less likely to be able to disassociate head and trunk.

When the children under five years of age were removed from the analysis, both arm position (p=.039) and disassociation (p=.027) were significant. This supports the second hypothesis: Children with an idiopathic toe walking gait will demonstrate postural control difficulties as evident by inability to maintain and poor position in the following position: Schilder's arm extension test compared to non-toe walking cohort. This also helps to support the possibility that difficulties processing information from the proprioceptive system may be an issue for some toe walkers.

The SPM-Home and SPM-P Home did not reveal any significant differences in the sensory processing of toe walkers when compared to age- and gender-matched peers in any of the areas, including body awareness (p=.526). The third hypothesis: Children with an idiopathic toe walking gait will have a different response to everyday sensory challenges as evident by parental responses to body awareness questions from the SPM-Home Form compared to the non-toe walking cohort, was not supported in this study.

There may have been several factors that contributed to the lack of significance with the SPM-Home and SPM-P Home. The age range for this study, 3 years to 13 years, required that both tools, the SPM-Home and SPM-P Home, were used. This may have led to difficulty analyzing the data. Another factor may have been the lack of control for other factors that could have predisposed the control group to sensory processing difficulties. For example, parents of three of the control participants anecdotally reported that their child had a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD). In

the literature, there is a significant correlation between ADHD and sensory processing disorders (Pfeiffer, Daly, Nicholls, & Gullo, 2015).

A third factor contributing to the lack of significance may have been the parents understanding of sensory processing and typical development. Parents of children who exhibited difficulties processing sensory information may not recognize this as atypical as their child has displayed the behavior for so long. For example, the parents of one idiopathic toe walker reported that their child, an 8-year-old boy, flapped his hands and jumped up and down when he was excited. The child also exhibited this behavior when PI was evaluating him. However, for question number 47 of the Body Awareness section of the SPM-Home: Does your child seem driven to seek activities such as pushing, pulling, dragging, lifting, and jumping? and question number 51 also from the Body Awareness section of the SPM-Home: Does you child jump a lot?, his parents indicated that he *Never* engages in these behaviors. The parents' report on the SPM-Home and SPM-P Home may not have accurately described their child's sensory needs. Parents may not have a clear understanding of the sensory systems. Parents may also have a strong desire for their child to be "normal" without any difficulties. Therefore, they may answer questions on a questionnaire that reflect typical behavior rather than the true observed behavior. The clinical observations may have been a more accurate gauge of the children's processing of proprioceptive information.

The results of this study corroborate other studies that have pointed toward a connection between ITW and sensory processing. Williams et al. (2014) found a connection between ITW, decreased motor skills, and sensory processing difficulties.

They found that children who are idiopathic toe walkers performed poorer on the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP); had a lower vibration perception threshold; performed poorer on the Standing Walking Balance subtest of the Sensory Integration and Praxis Test (SIPT); and demonstrated differences in the Sensory Seeking and Low Registration subtests of the Sensory Profile when compared with non-toe walking peers. The poorer performance on the BOTMP and Standing Walking Balance subtest of the SIPT both indicate difficulties registering input from the proprioceptive system and poor postural control may be a factor. A recent study looking at the center of pressure (CoP) for idiopathic toe walkers and non-toe walkers found greater between-group differences in CoP position under more complex sensory situations, such as on a foam surface with eyes closed (Koskovich et al., 2014). There were a small number of toe walkers (n=5) in the Koskovich et al. (2014) study; however, it points toward the connection between ITW and proprioception. The current study demonstrates a connection between these recent studies and solidifies the need for additional research in this area.

Clinical Application

This study indicates that there is a role for occupational therapists in working with children who exhibit an ITW gait pattern. Occupational therapists utilizing OA can help toe walkers learn how to adapt and reach relative mastery over occupational challenges. "Practice based on occupational adaptation differs from treatment that focuses on acquisition of functional skills because the practice model directs occupational therapy interventions toward the patient's internal processes and how such processes are

facilitated to improve occupational functioning" (Schultz & Schkade, 1992, p. 917). For children who toe walk due to difficulties responding to sensory cues from the proprioceptive system, the role of the occupational therapist is to guide the child toward participating in activities rich in sensory input, especially proprioception, and developing a greater understand of his/her sensory needs. This will help the child learn how to respond to, and meet, his/her own sensory needs. The goal of therapy is not to stop the toe walking, although this outcome may also be achieved. The goal of therapy is to help the child generate an appropriate adaptive response in order to respond to occupational challenges in various environments while engaging all three person systems: sensorimotor, cognitive, and psychosocial. When the child is able to engage the person systems and recognize how to regulate his/her sensory systems, he/she may be able to meet occupational challenges without toe walking.

Conclusion

This study supports the hypothesis that children who exhibit an idiopathic toe walking gait pattern may demonstrate decreased proprioceptive awareness and impaired postural control. In the exploratory study, idiopathic toe walkers had significantly more difficulty than non-toe walkers in maintaining positions requiring postural control and engagement of the proprioceptive system.

Limitations

This study included a small sample size for the ITW (n=15) and group control group (n=15). A smaller sample makes it difficult to find significant difference between the groups and it also makes it more difficult to generalize the results to a larger

population. The lack of differences between the toe walkers and control group on the SPM Home and SPM-P Home may have been due to this small size. The age range from 3 years, 11 months to 13 years, 2 months is also a limitation of the study as it may be difficult to generalize information across this age range. Both the SPM-Home and SPM-P Home were used to evaluate the sensory processing of these groups due to the ages of the children in the study. This could have been a factor in the lack of differences found between the toe walker and control group on these tools. The PI completed all of the testing/analyses and was not blinded to the groups. The lack of blinding could have led to biases and encouragement towards one of the groups. Following the same procedures and reciting the same directions for all participants accounted for this possible bias.

Implications/Future Research

This research contributes to the body of knowledge regarding ITW and sensory processing. It highlights the role of occupational therapists and evaluating sensory processing when working with children who exhibit an ITW gait pattern. The research cited indicates that surgical and non-surgical treatments for ITW have mixed effectiveness. Occupational therapists, utilizing the OA theory, are the prime individuals to provide sensory integration therapy in order to help regulate toe walkers sensory systems, decrease their need to engage in this gait pattern, and facilitate engagement in life roles and desired activities. Occupational therapists, working in collaboration with physical therapists, can also help to increase postural control, coordination, and appropriate body mechanics of idiopathic toe walkers. An occupational therapist can help

guide the child toward proprioceptive rich activities while the physical therapist engages that child in activities to increase strength and coordination.

Future studies should investigate the sensory and proprioceptive systems of idiopathic toe walkers with decreased variation in age, which would decrease the variability in the group. Larger studies focused on children closer in age, such as a study focusing on children between the ages of five and nine years old, would help to provide more insight into the sensory systems of toe walkers. Studies comparing toe walkers at various ages, including longitudinal studies, would help increase the understanding of the sensory needs of toe walkers. Another area for research is to look at the affects of toe walking on occupational performance and how occupation therapy with an OA focus could address performance needs. Additional research in implementing occupational therapy rich in proprioceptive input for idiopathic toe walkers is needed in order to verify this as an appropriate treatment model to address the needs of this population.

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APPENDIX A

Participant Flyer

Jessica McHugh, OTR/L affiliated with Texas Woman's University and AbleKids Pediatric Therapy

TOE WALKING AND POSTURAL CONTROL: GOING BEYOND THE TOES

Do you have a child who walks on his/her toes? Does you child walk up on toes without any medical condition? Jessica McHugh, OTR/L the owner of and occupational therapist at AbleKids Pediatric Therapy is conducting a study on children who walk on their toes with no known medical cause (idiopathic toe walking). This study will be conducted as part of a PhD in Occupational Therapy program through Texas Woman's University. It will include one brief session, approximately 30-45 minutes, in which your child will be observed in four different positions. The findings of this study will be useful in determining effective treatment for children who walk on their toes. You can give your child's physician or therapist permission to share your contact information with Jessica and you will receive a phone call to set up a time to meet or you can contact Jessica at (712) xxx-xxxx or Jessica@ablekidspeds.com if you have any questions or would like additional information.

APPENDIX B

Agency Approval Letters

Appendix F: Agency Approval Letter

2538 Glenn Ave * Sioux City, IA 51106 * ph. (712) 226-ABLE (2253) * Fax (712) 226-2257

11/01/14

Attention IRB committee at Texas Woman's University:

I give approval for the planned pilot study by Jessica McHugh, OTR/L to take place within the facility at AbleKids Pediatric Therapy. The proposed study will investigate the postural control of children who are idiopathic toe walkers and children with autism who toe walk. Children who do not toe walk and/or have autism will also be observed in this study as a comparison group. I understand that this study will include four brief observations along with completion of the Sensory Profile 2. A small treatment room will be made available for use of the study during the time period designated and I understand that information will be collected on the above listed areas as part of the study.

Jessica McHugh, OTR/L
Owner/Occupational Therapist
AbleKids Pediatric Therapy
(712) 226-2253
Jessica@ablekidspeds.com

Prairie Pediatrics & Adolescent Clinic PC

Ray C Sturdevant MD, Rex W Rundquist MD, Susan M Caldwell MD, Eyad K Najdawi MD
Patrick B Beck MD, Aimee M Lorenz MD, Ann E Rehan, MD, Nitya L. Brenner, MD
Marlene R Sturdevant ARNP, Nadine A Bergin ARNP, Susan B Sorenson ARNP, CPNP
Pediatric Cardiologist – Eyad K Najdawi MD

November 5, 2014

ATTN: IRB committee at Texas Woman's University

To Whom It May Concern:

We give approval for our office to participate in a planned pilot study by Jessica McHugh, OTR/L. The proposed study will investigate the postural control of children who are idiopathic toe walkers (ITW) and children with autism who toe walk.

Children who do not toe walk and/or have autism will also be observed in this study as a comparison group. We understand that this study will include four brief observations along with completion of the Sensory Profile 2.

Our role in this study will be limited to asking parents of children who are ITW or children with autism who toe walk if we can give their contact information to Jessica McHugh. We will also give parents a copy of a flyer provided by Jessica McHugh to give them information about the study.

Sincerely,

Rehan MD

Prairie Pediatrics & Adolescent Clinic, PC

APPENDIX C

The Toe Walking Tool

	Toe Walking Tool *Williams CM, Tinley P, Curtin M. The Toe Walking Tool: a novel method for assessing idiopathic toe walking children. Gait Posture. 2010;32(4):508-511.* ***Instructions: Complete questions 1-19 and 25-26 with the parent and complete questions 19-24 based on observation and examination in order to determine a response that may indicate a medical cause.***	**Child's Response**	**Theme** (D = demographic; NG = Neurogenic; NM = Neuromuscular; T = Trauma)	**Response that may indicate a medical cause**
1	Name:		D	N/A
2	Date of Birth:		D	N/A
3	Gender	☐ M ☐ F	D	N/A
4	Does the child toe walk?	☐ Y ☐N	D	N/A
5	Does the child have a condition that you have sought medical assistance for and/or been diagnosed with a condition causing toe walking?	☐ Y ☐N	D	N/A
6	Does the child have a diagnosis of autism spectrum disorder?	☐ Y ☐ N	NG	Yes
7	Does the child have a diagnosis of cerebral palsy?	☐ Y ☐ N	NM	Yes
8	Does the child have a diagnosis of muscular dystrophy?	☐ Y ☐ N	NM	Yes
9	Does the child's family have a history of muscular dystrophy?	☐ Y ☐ N	NM	Yes
10	Does the child have a diagnosis of global developmental delay?	☐ Y ☐ N	NG	Yes
11	When the child was born, was their birth weight over 2500 g (5.5 pounds)?	☐ Y ☐ N	NM	No
12	When the child was born were they over 37 weeks of gestation?	☐ Y ☐ N	NM	No
13	Was the child admitted to special needs nursery/neonatal intensive care after birth?	☐ Y ☐ N	NM	Yes
14	Did the child independently walk prior to 20 months of age?	☐ Y ☐ N	NG / NM	No
15	Does the child have a family member that toe	☐ Y	D	N/A

	walks with no other medical condition?	☐ N		
16	Does the child toe walk on one foot only?	☐ Y ☐ N	T	Yes
17	Is the child toe walking in response to pain?	☐ Y ☐ N	T	Yes
18	Did the child previously walk flat-footed and only recently start to toe walk?	☐ Y ☐ N	T / NM	Yes
19	When you ask the child to walk on their heels are they able to?	☐ Y ☐ N	T/ NM	No
20	On testing the ankle or hamstring range of motion is there a clonus and/or catch?	☐ Y ☐ N	NM	No
21	When asking the child to get up from the floor is there a positive Gower's sign?	☐ Y ☐ N	NM	Yes
22	Is there are normal knee jerk reflex?	☐ Y ☐ N	NM	No
23	Is there a normal babinski reflex?	☐ Y ☐ N	NM	No
24	a. Are the hip flexors tight for the child's age (Thomas test)? b. Are the hamstrings tight for the child's age (Popliteal Angle)? c. Is the gastrocnemius and soleus tight for the child's age (Lunge Test)?	☐ Y ☐ N ☐ Y ☐ N ☐ Y ☐ N	NM	Answer of "Yes" for two of the questions
25	Does the child have more than 2 significant delayed developmental milestones?	☐ Y ☐ N	NG	Yes
26	Does the child have limited eye contact, have strict rituals or ritual related behaviors, i.e., lining up toys, rocking or spinning?	☐ Y ☐ N	NG	Yes

APPENDIX D

Pilot Study Results by Participant

Toe Walker
AGE: 3:0 Sex: F BMI: 16.2
Control
AGE: 3:1 Sex: F BMI: 16.3

Test	Toe Walker	Control
Tall Kneel with Reach	2 inches	7 inches
Wall Squat	4 seconds	5 seconds
Supine Flexion	3 seconds	6 seconds
Prone Extension	0 seconds	3 seconds

Sensory Profile 2	Toe Walker	Control
Seeking	Just like other	Much more
Avoiding	Just like other	More than others
Sensitivity	Just like other	More than others
Registration	Just like other	More than others
Auditory	Less than others	Just like others
Visual	Just like other	More than others
Touch	Just like other	More than others
Movement	Just like other	More than others
Body Position	Just like other	Just like other
Oral	Just like other	Just like other
Conduct	Just like other	Much more
Social Emotional	Just like other	Just like other
Attentional	Just like other	Just like other

Toe Walker
AGE: 5:5 Sex: F BMI: 15.2
Control
AGE: 5:2 Sex: F BMI: 15.4

Test	Toe Walker	Control
Tall Kneel with Reach	5 inches	6.25 inches
Wall Squat	21 seconds	30 seconds
Supine Flexion	6 seconds	9 seconds
Prone Extension	32 seconds	20 seconds

Sensory Profile 2	Toe Walker	Control
Seeking	Just like others	Just like others
Avoiding	Just like others	Just like others
Sensitivity	Just like others	Just like others
Registration	Just like others	Just like others
Auditory	Just like others	Less than others
Visual	Just like others	Just like others
Touch	Just like others	Just like others
Movement	Just like others	Just like others
Body Position	Just like others	Just like others
Oral	Just like others	Just like others
Conduct	Just like others	Just like others
Social Emotional	Just like others	Just like others
Attentional	Just like others	Just like others

Toe Walker
AGE: 6:3 Sex: M BMI: 17.3
Control
AGE: 6:2 Sex: M BMI: 17.1

Test	Toe Walker	Control
Tall Kneel with Reach	5 inches	11 inches
Wall Squat	28 seconds	35 seconds
Supine Flexion	6 seconds	19 seconds
Prone Extension	13 seconds	26 seconds

Sensory Profile 2	Toe Walker	Control
Seeking	Just like others	Just like others
Avoiding	Just like others	Just like others
Sensitivity	Just like others	Just like others
Registration	Just like others	Just like others
Auditory	Just like others	Just like others
Visual	Just like others	Just like others
Touch	Just like others	Just like others
Movement	Just like others	Just like others
Body Position	Just like others	Just like others
Oral	More than others	Just like others
Conduct	Just like others	Just like others
Social Emotional	Less than others	Just like others
Attentional	Just like others	Just like others

Toe Walker
AGE: 6:10 Sex: F BMI: 16.6
Control
AGE: 6:9 Sex: F BMI: 16.8

Test	Toe Walker	Control
Tall Kneel with Reach	7 inches	10 inches
Wall Squat	30 seconds	98 seconds
Supine Flexion	16 seconds	32 seconds
Prone Extension	18 seconds	45 seconds

Sensory Profile 2	Toe Walker	Control
Seeking	Just like others	Less than others
Avoiding	Just like others	Less than others
Sensitivity	Just like others	Just like others
Registration	More than others	Just like others
Auditory	Just like others	Less than others
Visual	Just like others	Less than others
Touch	Just like others	Just like others
Movement	Just like others	Just like others
Body Position	Much more	Just like others
Oral	Just like others	Just like others
Conduct	Just like others	Just like others
Social Emotional	Just like others	Just like others
Attentional	More than others	Just like others

Toe Walker
AGE: 7:0 Sex: F BMI: 16.7
Control
AGE: 7:3 Sex: F BMI: 16.9

Test	Toe Walker	Control
Tall Kneel with Reach	8 inches	11 inches
Wall Squat	26 seconds	50 seconds
Supine Flexion	23 seconds	58 seconds
Prone Extension	22 seconds	98 seconds

Sensory Profile 2	Toe Walker	Control
Seeking	Just like others	More than others
Avoiding	Just like others	More than others
Sensitivity	Just like others	Just like others
Registration	Just like others	Just like others
Auditory	Just like others	More than others
Visual	Just like others	More than others
Touch	Just like others	Just like others
Movement	Just like others	Just like others
Body Position	Just like others	Just like others
Oral	Just like others	Just like others
Conduct	Just like others	Just like others
Social Emotional	Just like others	Just like others
Attentional	Just like others	Just like others

Toe Walker
AGE: 7:4 Sex: M BMI: 20.9
Control
AGE: 7:4 Sex: M BMI: 20.5

Test	Toe Walker	Control
Tall Kneel with Reach	7 inches	11 inches
Wall Squat	9 seconds	62 seconds
Supine Flexion	20 seconds	70 seconds
Prone Extension	30 seconds	67 seconds

Sensory Profile 2	Toe Walker	Control
Seeking	Just like others	More than others
Avoiding	Much more	Just like others
Sensitivity	Much more	More than others
Registration	Much more	Just like others
Auditory	Much more	More than others
Visual	Just like others	Just like others
Touch	Just like others	Just like others
Movement	Just like others	More than others
Body Position	Much more	Just like others
Oral	More than others	More than others
Conduct	More than others	Just like others
Social Emotional	Much more	Just like others
Attentional	More than others	More than others

Toe Walker
AGE: 11:4 Sex: M BMI: 17.0
Control
AGE: 11:1 Sex: M BMI: 17.2

Test	Toe Walker	Control
Tall Kneel with Reach	12 inches	16 inches
Wall Squat	35 seconds	60 seconds
Supine Flexion	20 seconds	60 seconds
Prone Extension	60 seconds	67 seconds

Sensory Profile 2	Toe Walker	Control
Seeking	Just like others	Just like others
Avoiding	Just like others	Just like others
Sensitivity	More than others	Just like others
Registration	Just like others	Just like others
Auditory	Just like others	Just like others
Visual	Less than others	Just like others
Touch	More than others	Just like others
Movement	Less than others	Just like others
Body Position	More than others	Just like others
Oral	More than others	Just like others
Conduct	Just like others	Just like others
Social Emotional	More than others	Just like others
Attentional	Just like others	Less than others

Toe Walker
AGE: 12:1 Sex: F BMI: 26.6
Control
AGE: 12:3 Sex: F BMI: 26.2

Test	Toe Walker	Control
Tall Kneel with Reach	14.5 inches	15 inches
Wall Squat	28 seconds	103 seconds
Supine Flexion	30 seconds	163 seconds
Prone Extension	73 seconds	121 seconds

Sensory Profile 2	Toe Walker	Control
Seeking	Just like others	Less than others
Avoiding	Just like others	Just like others
Sensitivity	Just like others	Just like others
Registration	Just like others	Just like others
Auditory	Less than others	Less than others
Visual	Just like others	Less than others
Touch	Just like others	Just like others
Movement	Just like others	Just like others
Body Position	Just like others	Just like others
Oral	Just like others	Just like others
Conduct	Just like others	Just like others
Social Emotional	Just like others	Just like others
Attentional	Just like others	Just like others

APPENDIX E

Pilot Study Results by Test

Tall Kneel Reach (Modified Reach Test)

	ITWs	Non-Toe Walkers	Difference
Total	153.67 cm	221.62 cm	67.95 cm
Average	19.21 cm	27.70 cm	8.49 cm

Tall Kneel Reach by Age

Age	ITWs (cm)	Non-Toe Walkers (cm)
3F	5.08	17.78
5F	12.7	15.875
6M	12.7	27.94
6F	17.78	25.4
7M	17.78	27.94
7F	20.32	27.94
11M	30.48	40.64
12F	36.83	38.1

*Pediatric Reach Test versus Study Results**

Age	Mean (Donahoe, et al. 1994; Volkman, et al.)	Critical Reach (-2SD)	Control	ITW
5-6	21.17	16.79	22.07 (N=3)	14.39 (N=3)
7-8	24.21	20.57	27.94 (N=2)	19.05 (N=2)
9-10	27.97	25.56	NA	NA
11-12	32.79	29.68	39.37 (N=2)	33.66 (N=2)
13-15	32.30	29.58	NA	NA

*The position used in this study is not the Pediatric Reach Test but a variation of it as the children are in a kneeling rather than standing position. This chart is only for anecdotal use, as the results cannot be compared statistically.

Wall Squat

	ITWs	Non-Toe Walkers	Difference
Total	181 seconds	443 seconds	262 seconds
Average	22.63 seconds	55.38 seconds	32.75 seconds

Wall Squat by Age (in seconds)

Age	ITWs	Non-Toe Walkers
3F	4	5
5F	21	30
6M	28	35
7M	9	62
6F	30	98
7F	26	50
11M	35	60
12F	28	103

Supine Flexion

	ITWs	Non-Toe Walkers	Difference
Total	124 seconds	417seconds	293 seconds
Average	15.5 seconds	52.13 seconds	36.63 seconds

Supine Flexion by Age (in seconds)

Age	ITWs	Non-Toe Walkers
3F	3	6
5F	6	9
6M	6	19
6F	16	32
7M	20	70
7F	23	58
11M	20	60
12F	30	163

Supine Flexion Averages versus Study Results

Age	Average (Fraser, 1983)	Control	ITW
4	10	NA	NA
5	21	9	6
6	37	32	16
7	57	64 (N=2)	21.5 (N=2)
8	104	NA	NA

Prone Extension

	ITWs	Non-Toe Walkers	Difference
Total	248 seconds	447 seconds	199 seconds
Average	31 seconds	55.88 seconds	24.88 seconds

Prone Extension by Age (in seconds)

Age	ITWs	Non-Toe Walkers
3F	0	3
5F	32	20
6M	13	26
6F	18	45
7M	30	67
7F	22	98
11M	60	67
12F	73	121

Prone Extension Averages versus Study Results

Age	Mean (Bowman & Katz, 1984)	Control	ITW
4	18.15	20 (5 yo)	32 (5 yo)
6	28.93	45	18
8	30	NA	NA

APPENDIX F

Sensory Processing Measure-Home Form

sensory spm Sensory Processing Measure

Home Form
Profile Sheet

L. Diane Parham, Ph.D., OTR/L, FAOTA,
and Cheryl Ecker, M.A., OTR/L

wps

Name (or ID#): _____ Age: _____ Grade: _____ Gender: ☐ M ☐ F

Date this form completed: _____ Reason for assessment: _____

%ile	T	SOC	VIS	HEA	TOU	BOD	BAL	PLA	TOT	T	%ile
	80	37–40	35–44	29–32	37–44	36–40	35–44	33–36	170–224	80	
	79	35–36	33–34	27–28	36	34–35	34	31–32	164–169	79	
	78	34	32	26	34–35	33	33		154–163	78	
	77		31	25	33	32	31–32	30	142–153	77	
	76	33	30	24		31	29–30		140–141	76	
	75	32	28–29	23	32	30	27–28	29	137–139	75	
>99	74		27	22	30–31	29	26	28	133–136	74	>99
99	73	31			28–29	28		27	131–132	73	99
	72		26	21	27	27	25	26	129–130	72	
98	71	30	25	20	26	26	24		122–128	71	98
	70	29	24	19		25		25	119–121	70	
97	69	28	23	18	25	24	23	24	110–118	69	97
96	68		21–22	17	23–24	23	22		106–109	68	96
	67	27	20	16	22	22		23	103–105	67	
95	66	26		15	21	21	21	22	99–102	66	95
93	65	25	19		20	20	20	21	94–98	65	93
92	64	24	18	14	19	19	19	20	92–93	64	92
90	63	23	17	13	18	18	18	19	88–91	63	90
88	62	22		12					84–87	62	88
86	61		16		17	17	17	18	81–83	61	86
84	60	21				16		17	79–80	60	84
82	59		15	11	16	15	16		77–78	59	82
79	58	20						16	75–76	58	79
76	57		14		15	14	15	15	73–74	57	76
73	56	19		10					71–72	56	73
69	55	18			14	13		14	70	55	69
66	54		13				14		69	54	66
62	53	17						13	67–68	53	62
58	52			9	13	12			66	52	58
54	51	16					13	12	65	51	54
50	50		12						64	50	50
46	49	15								49	46
42	48					11		11	63	48	42
38	47	14			12		12		62	47	38
34	46								61	46	34
31	45	13						10		45	31
27	44								60	44	27
24	43	12		8						43	24
21	42								59	42	21
18	41		11							41	18
16	40	10–11			11	10	11	9	56–58	40	16
%ile	T	SOC	VIS	HEA	TOU	BOD	BAL	PLA	TOT	T	%ile

	SOC	VIS	HEA	TOU	BOD	BAL	PLA	TOT	
Raw Score ▶	____	____	____	____	____	____	____	____	◀ Raw Score
T-Score ▶	____	____	____	____	____	____	____	____	◀ T-Score
Interpretive Range									
Typical (40T–59T)	☐	☐	☐	☐	☐	☐	☐	☐	
Some Problems (60T–69T)	☐	☐	☐	☐	☐	☐	☐	☐	
Definite Dysfunction (70T–80T)	☐	☐	☐	☐	☐	☐	☐	☐	

DIF Calculation

Home Form TOT *T*-score _____

Main Classroom Form TOT *T*-score – _____

Environment Difference (DIF) = _____

DIF Interpretation

- ☐ *DIF* ≥ 15 — DEFINITE difference: More problems in *Home* than in *Main Classroom*
- ☐ 14 ≥ *DIF* ≥ 10 — PROBABLE difference: More problems in *Home* than in *Main Classroom*
- ☐ 9 ≥ *DIF* ≥ –9 — NO difference in amount of problems between *Main Classroom* and *Home*
- ☐ –10 ≥ *DIF* ≥ –14 — PROBABLE difference: More problems in *Main Classroom* than in *Home*
- ☐ –15 ≥ *DIF* — DEFINITE difference: More problems in *Main Classroom* than in *Home*

EXAMINER: REMOVE THIS SHEET BEFORE COMPLETING FORM.

Additional copies of this form (W-466A) may be purchased from WPS. Please contact us at **800.648.8857** or **www.wpspublish.com**.

W-466A

SPM Sensory Processing Measure

AutoScore™ Form

L. Diane Parham, Ph.D., OTR/L, FAOTA,
and Cheryl Ecker, M.A., OTR/L

WPS

Home

Parent/Guardian Information

Your Name/ID#: _____ Your Relationship to Child: _____ Today's Date: _____

Child Information

Child's Name/ID#: _____ Child's Gender: ☐ M ☐ F Child's Age: ____Years ____Months Child's Grade: _____

Race/Ethnicity:

☐ American Indian/Alaska Native ☐ Asian ☐ Black/African American ☐ Hispanic/Latino ☐ Native Hawaiian/Pacific Islander ☐ White ☐ Other

Comments on child's behavior/functioning: _____

DIRECTIONS

Please answer the questions on this form based on your *child's typical behavior during the past month*. Use the following rating scale:

Never: the behavior *never* or *almost never* happens
Occasionally: the behavior happens *some of the time*
Frequently: the behavior happens *much of the time*
Always: the behavior *always* or *almost always* happens

Circle the *one* answer that best describes how often the behavior happens. Try your best to answer all of the questions.

Several questions ask whether your child shows "distress" in certain situations. Showing distress may include verbal expressions (whining, crying, yelling) or nonverbal expressions (withdrawing, gesturing, pushing something away, running away, wincing, striking out).

You may use the space provided above to add any additional comments on your child's behavior or functioning.

PLEASE PRESS HARD WHEN CIRCLING YOUR RESPONSES.

Never	Occasionally	Frequently	Always		
					SOCIAL PARTICIPATION *Does your child...*
N	O	F	A	1.	Play with friends cooperatively (without lots of arguments)?
N	O	F	A	2.	Interact appropriately with parents and other significant adults (communicates well, follows directions, shows respect, etc.)?
N	O	F	A	3.	Share things when asked?
N	O	F	A	4.	Carry on a conversation without standing or sitting too close to others?
N	O	F	A	5.	Maintain appropriate eye contact during conversation?
N	O	F	A	6.	Join in play with others without disrupting the ongoing activity?
N	O	F	A	7.	Take part in appropriate mealtime conversation and interaction?
N	O	F	A	8.	Participate appropriately in family outings, such as dining out or going to a park, museum, or movie?
N	O	F	A	9.	Participate appropriately in family gatherings, such as holidays, weddings, and birthdays?
N	O	F	A	10.	Participate appropriately in activities with friends, such as parties, going to the mall, and riding bikes/skateboards/scooters?
					VISION *Does your child...*
N	O	F	A	11.	Seem bothered by light, especially bright light (blinks, squints, cries, closes eyes, etc.)?
N	O	F	A	12.	Have trouble finding an object when it is part of a group of other things?
N	O	F	A	13.	Close one eye or tip his or her head back when looking at something or someone?
N	O	F	A	14.	Become distressed in unusual visual environments, such as a bright, colorful room or a dimly lit room?
N	O	F	A	15.	Have difficulty controlling eye movement when following objects like a ball with his or her eyes?
N	O	F	A	16.	Have difficulty recognizing how objects are similar or different based on their colors, shapes, or sizes?
N	O	F	A	17.	Enjoy watching objects spin or move more than most kids his or her age?
N	O	F	A	18.	Walk into objects or people as if they were not there?
N	O	F	A	19.	Like to flip light switches on and off repeatedly?
N	O	F	A	20.	Dislike certain types of lighting, such as midday sun, strobe lights, flickering lights, or fluorescent lights?
N	O	F	A	21.	Enjoy looking at moving objects out of the corner of his or her eye?
					HEARING *Does your child...*
N	O	F	A	22.	Seem bothered by ordinary household sounds, such as the vacuum cleaner, hair dryer, or toilet flushing?
N	O	F	A	23.	Respond negatively to loud noises by running away, crying, or holding hands over ears?
N	O	F	A	24.	Appear not to hear certain sounds?
N	O	F	A	25.	Seem disturbed by or intensely interested in sounds not usually noticed by other people?
N	O	F	A	26.	Seem frightened of sounds that do not usually cause distress in other kids his or her age?
N	O	F	A	27.	Seem easily distracted by background noises such as a lawn mower outside, an air conditioner, a refrigerator, or fluorescent lights?
N	O	F	A	28.	Like to cause certain sounds to happen over and over again, such as by repeatedly flushing the toilet?
N	O	F	A	29.	Show distress at shrill or brassy sounds, such as whistles, party noisemakers, flutes, and trumpets?

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Additional copies of this form (W-466A) may be purchased from WPS. Please contact us at **800.648.8857** or **www.wpspublish.com**.

W-466A

PLEASE PRESS HARD WHEN CIRCLING YOUR RESPONSES.

Never	Occasionally	Frequently	Always		
				TOUCH	*Does your child…*
N	O	F	A	**30.**	Pull away from being touched lightly?
N	O	F	A	**31.**	Seem to lack normal awareness of being touched?
N	O	F	A	**32.**	Become distressed by the feel of new clothes?
N	O	F	A	**33.**	Prefer to touch rather than to be touched?
N	O	F	A	**34.**	Become distressed by having his or her fingernails or toenails cut?
N	O	F	A	**35.**	Seem bothered when someone touches his or her face?
N	O	F	A	**36.**	Avoid touching or playing with finger paint, paste, sand, clay, mud, glue, or other messy things?
N	O	F	A	**37.**	Have an unusually high tolerance for pain?
N	O	F	A	**38.**	Dislike teeth brushing, more than most kids his or her age?
N	O	F	A	**39.**	Seem to enjoy sensations that should be painful, such as crashing onto the floor or hitting his or her own body?
N	O	F	A	**40.**	Have trouble finding things in a pocket, bag, or backpack using touch only (without looking)?
				TASTE AND SMELL	*Does your child…*
N	O	F	A	**41.**	Like to taste nonfood items, such as glue or paint?
N	O	F	A	**42.**	Gag at the thought of an unappealing food, such as cooked spinach?
N	O	F	A	**43.**	Like to smell nonfood objects and people?
N	O	F	A	**44.**	Show distress at smells that other children do not notice?
N	O	F	A	**45.**	Seem to ignore or not notice strong odors that other children react to?
				BODY AWARENESS	*Does your child…*
N	O	F	A	**46.**	Grasp objects (such as a pencil or spoon) so tightly that it is difficult to use the object?
N	O	F	A	**47.**	Seem driven to seek activities such as pushing, pulling, dragging, lifting, and jumping?
N	O	F	A	**48.**	Seem unsure of how far to raise or lower the body during movement such as sitting down or stepping over an object?
N	O	F	A	**49.**	Grasp objects (such as a pencil or spoon) so loosely that it is difficult to use the object?
N	O	F	A	**50.**	Seem to exert too much pressure for the task, such as walking heavily, slamming doors, or pressing too hard when using pencils or crayons?
N	O	F	A	**51.**	Jump a lot?
N	O	F	A	**52.**	Tend to pet animals with too much force?
N	O	F	A	**53.**	Bump or push other children?
N	O	F	A	**54.**	Chew on toys, clothes, or other objects more than other children?
N	O	F	A	**55.**	Break things from pressing or pushing too hard on them?
				BALANCE AND MOTION	*Does your child…*
N	O	F	A	**56.**	Seem excessively fearful of movement, such as going up and down stairs or riding swings, teeter-totters, slides, or other playground equipment?
N	O	F	A	**57.**	Have good balance?
N	O	F	A	**58.**	Avoid balance activities, such as walking on curbs or on uneven ground?
N	O	F	A	**59.**	Fall out of a chair when shifting his or her body?
N	O	F	A	**60.**	Fail to catch himself or herself when falling?
N	O	F	A	**61.**	Seem not to get dizzy when others usually do?
N	O	F	A	**62.**	Spin and whirl his or her body more than other children?
N	O	F	A	**63.**	Show distress when his or her head is tilted away from the upright, vertical position?
N	O	F	A	**64.**	Show poor coordination and appear to be clumsy?
N	O	F	A	**65.**	Seem afraid of riding in elevators or on escalators?
N	O	F	A	**66.**	Lean on other people or furniture when sitting or when trying to stand up?
				PLANNING AND IDEAS	*Does your child…*
N	O	F	A	**67.**	Perform inconsistently in daily tasks?
N	O	F	A	**68.**	Have trouble figuring out how to carry multiple objects at the same time?
N	O	F	A	**69.**	Seem confused about how to put away materials and belongings in their correct places?
N	O	F	A	**70.**	Fail to perform tasks in proper sequence, such as getting dressed or setting the table?
N	O	F	A	**71.**	Fail to complete tasks with multiple steps?
N	O	F	A	**72.**	Have difficulty imitating demonstrated actions, such as movement games or songs with motions?
N	O	F	A	**73.**	Have difficulty building to copy a model, such as using Legos or blocks to build something that matches a model?
N	O	F	A	**74.**	Have trouble coming up with ideas for new games and activities?
N	O	F	A	**75.**	Tend to play the same activities over and over, rather than shift to new activities when given the chance?

APPENDIX G

Sensory Processing Measure- Preschool Home Form

Sensory Processing Measure-Preschool Home Form

Cheryl Ecker, M.A., OTR/L,
and L. Diane Parham, Ph.D., OTR/L, FAOTA

Summary Sheet Ages 3

Name (or ID#): _____ Age: _____ Gender: ☐ M ☐ F

Date this form completed: _____ Reason for assessment: _____

		SOC	VIS	HEA	TOU	BOD	BAL	PLA	TOT		
	80	28–32	38–44	30–36	36–56	27–36	33–44	29–36	153–232	80	
	79	27	37	29		26			151–152	79	
	78			28		25		28	149–150	78	
	77		35–36	27	35	24	32	27	148	77	
	76	26	32–34	26	34	23	28–31	25–26	141–147	76	
	75	25	30–31	25			24–27	23–24	140	75	
>99	74		29		33	22		21–22	139	74	>99
99	73	24	28	24			23		137–138	73	99
	72		26–27	22–23	32	21	22	20	119–136	72	
98	71	23	25	21	31	20	21	19	113–118	71	98
	70	22	24	20	30		20		111–112	70	
97	69	21	23	19	29	19		18	106–110	69	97
96	68	20			28	18	19		104–105	68	96
	67	19	22	18	27		17–18	17	99–103	67	
95	66	18	21	17	26	17			95–98	66	95
93	65				25	16		16	93–94	65	93
92	64		20	16	24		16	15	91–92	64	92
90	63	17		15	23				89–90	63	90
88	62		19		22	15	15		88	62	88
86	61							14	86–87	61	86
84	60		18	14	21	14			84–85	60	84
82	59	16							82–83	59	82
79	58		17	13	20		14	13	80–81	58	79
76	57					13			79	57	76
73	56	15	16						77–78	56	73
69	55			12	19		13	12	76	55	69
66	54	14				12			75	54	66
62	53		15		18				74	53	62
58	52	13		11				11	72–73	52	58
54	51								71	51	54
50	50	12	14			11	12		70	50	50
46	49				17				69	49	46
42	48							10	68	48	42
38	47	11	13	10					67	47	38
34	46				16	10			66	46	34
31	45								65	45	31
27	44	10								44	27
24	43		12		15				64	43	24
21	42						11		63	42	21
18	41									41	18
16	40	8–9	11	9	14	9		9	58–62	40	16
		SOC	VIS	HEA	TOU	BOD	BAL	PLA	TOT		
Raw Score ▶		____	____	____	____	____	____	____	____	**◀ Raw Score**	
***T*-Score ▶**		____	____	____	____	____	____	____	____	***T*-Score ◀**	
Interpretive Range											
Typical (40T–59T)		☐	☐	☐	☐	☐	☐	☐	☐		
Some Problems (60T–69T)		☐	☐	☐	☐	☐	☐	☐	☐		
Definite Dysfunction (70T–80T)		☐	☐	☐	☐	☐	☐	☐	☐		

DIF Calculation

Home Form TOT *T*-score _____
School Form TOT *T*-score – _____
Environment Difference (DIF) = _____

DIF Interpretation

- ☐ *DIF* ≥ 15 — DEFINITE difference: More problems in *Home* than in *School*
- ☐ 14 ≥ *DIF* ≥ 10 — PROBABLE difference: More problems in *Home* than in *School*
- ☐ 9 ≥ *DIF* ≥ –9 — NO difference in amount of problems between *School* and *Home*
- ☐ –10 ≥ *DIF* ≥ –14 — PROBABLE difference: More problems in *School* than in *Home*
- ☐ –15 ≥ *DIF* — DEFINITE difference: More problems in *School* than in *Home*

W-497A

Sensory Processing Measure–Preschool HOME

Cheryl Ecker, M.A., OTR/L,
and L. Diane Parham, Ph.D., OTR/L, FAOTA

AutoScore™ Form

Parent/Guardian Information

Your Name/ID#: _____

Your Relationship to Child: _____ Today's Date: _____

Child Information

Child's Name/ID#: _____

Child's Gender: ☐ M ☐ F Child's Age: _____ Years _____ Months

Race/Ethnicity:

☐ American Indian/Alaska Native ☐ Asian ☐ Black/African American

☐ Hispanic/Latino ☐ Native Hawaiian/Pacific Islander ☐ White ☐ Other

Comments on child's behavior/functioning: _____

_____

_____

Directions

Please answer the questions on this form based on your *child's typical behavior during the past month.* Use the following rating scale:

Never: The behavior *never* or *almost never* happens

Occasionally: The behavior happens *some of the time*

Frequently: The behavior happens *much of the time*

Always: The behavior *always* or *almost always* happens

Circle the *one* answer that best describes how often the behavior happens. Try your best to answer all of the questions.

Several questions ask whether your child shows "distress" in certain situations. Showing distress may include verbal expressions (whining, crying, yelling) or nonverbal expressions (withdrawing, gesturing, pushing something away, running away, wincing, striking out).

You may use the space provided on the left to add any comments on your child's behavior or functioning.

PLEASE PRESS HARD WHEN CIRCLING YOUR RESPONSES.

Never	Occasionally	Frequently	Always		
					SOCIAL PARTICIPATION *This child...*
N	O	F	A	1.	Plays with friends cooperatively.
N	O	F	A	2.	Shares things when asked.
N	O	F	A	3.	Joins in play with others without disrupting the ongoing activity.
N	O	F	A	4.	Takes part in appropriate mealtime interactions.
N	O	F	A	5.	Participates appropriately in family outings, such as dining out or going to a park or museum.
N	O	F	A	6.	Participates appropriately in family gatherings, such as holidays, weddings, and birthdays.
N	O	F	A	7.	Participates appropriately in activities with friends, such as parties, using playground equipment, and riding tricycles.
N	O	F	A	8.	Cooperates during family errands, such as grocery shopping or picking up siblings from school.
					VISION *This child...*
N	O	F	A	9.	Seems bothered by light, especially bright light (blinks, squints, cries, closes eyes, etc.).
N	O	F	A	10.	Has trouble finding an object when it is part of a group of other things.
N	O	F	A	11.	Has difficulty recognizing how objects are similar or different based on their colors, shapes, or sizes.
N	O	F	A	12.	Enjoys watching objects spin or move more than most children his or her age.
N	O	F	A	13.	Walks into objects or people as if they were not there.
N	O	F	A	14.	Likes to flip light switches on and off repeatedly.
N	O	F	A	15.	Enjoys looking at moving objects out of the corner of his or her eye.
N	O	F	A	16.	Has trouble paying attention if there are a lot of things to look at.
N	O	F	A	17.	Becomes bothered by busy visual environments, such as a cluttered room or a store with a lot of items.
N	O	F	A	18.	Becomes easily distracted by looking at things while walking.
N	O	F	A	19.	Has trouble completing simple tasks when there are many things to look at.
					HEARING *This child...*
N	O	F	A	20.	Seems bothered by ordinary household sounds, such as the vacuum cleaner, hair dryer, or toilet flushing.
N	O	F	A	21.	Responds negatively to loud noises by running away, crying, or holding hands over ears.
N	O	F	A	22.	Appears not to hear certain sounds.
N	O	F	A	23.	Seems disturbed by or intensely interested in sounds not usually noticed by other people.
N	O	F	A	24.	Seems easily distracted by background noises, such as a lawn mower outside, an air conditioner, a refrigerator, or fluorescent lights.
N	O	F	A	25.	Likes to cause certain sounds to happen over and over again, such as by repeatedly flushing the toilet.
N	O	F	A	26.	Shows distress at shrill or brassy sounds, such as whistles, party noisemakers, flutes, and trumpets.
N	O	F	A	27.	Becomes distressed by busy sounds, such as a party or a crowded room.
N	O	F	A	28.	Startles easily when hearing a loud or unexpected sound.

continue on back page...

WPS. Additional copies of this form (W-497A) may be purchased from WPS. Please contact us at **800.648.8857** or **www.wpspublish.com**.

PLEASE PRESS HARD WHEN CIRCLING YOUR RESPONSES.

Never Occasionally Frequently Always

TOUCH *This child...*

N ..... O .....F.....A ..... **29.** Pulls away from being touched lightly.
N ..... O .....F.....A ..... **30.** Prefers to touch rather than to be touched.
N ..... O .....F.....A ..... **31.** Becomes distressed by having his or her fingernails cut.
N ..... O .....F.....A ..... **32.** Seems bothered when someone touches his or her face.
N ..... O .....F.....A ..... **33.** Avoids touching or playing with finger paint, paste, sand, clay, mud, glue, or other messy things.
N ..... O .....F.....A ..... **34.** Has an unusually high tolerance for pain.
N ..... O .....F.....A ..... **35.** Dislikes teeth brushing, more than most children his or her age.
N ..... O .....F.....A ..... **36.** Seems to enjoy sensations that should be painful, such as crashing onto the floor or hitting his or her own body.
N ..... O .....F.....A ..... **37.** Dislikes having his or her hair combed, brushed, or styled.
N ..... O .....F.....A ..... **38.** Dislikes having his or her hair cut.
N ..... O .....F.....A ..... **39.** Avoids eating foods of certain textures.
N ..... O .....F.....A ..... **40.** Gags or vomits in response to foods of certain textures.
N ..... O .....F.....A ..... **41.** Dislikes having his or her face washed or wiped.
N ..... O .....F.....A ..... **42.** Drools more than most children his or her age.

TASTE AND SMELL *This child...*

N ..... O .....F.....A ..... **43.** Likes to taste nonfood items, such as glue or paints.
N ..... O .....F.....A ..... **44.** Seems to ignore or not notice strong odors to which other children react.
N ..... O .....F.....A ..... **45.** Prefers certain food tastes to the point of refusing to eat any other foods offered.
N ..... O .....F.....A ..... **46.** Refuses to use toothpaste on the toothbrush.

BODY AWARENESS *This child...*

N ..... O .....F.....A ..... **47.** Grasps objects (such as a pencil or spoon) so tightly that it is difficult to use the object.
N ..... O .....F.....A ..... **48.** Seems driven to seek activities such as pushing, pulling, dragging, lifting, and jumping.
N ..... O .....F.....A ..... **49.** Seems unsure of how far to raise or lower the body during movement such as sitting down or stepping over an object.
N ..... O .....F.....A ..... **50.** Grasps objects (such as a pencil or spoon) so loosely that it is difficult to use the object.
N ..... O .....F.....A ..... **51.** Seems to exert too much pressure for the task, such as walking heavily, slamming doors, or pressing too hard when using pencils or crayons.
N ..... O .....F.....A ..... **52.** Jumps a lot.
N ..... O .....F.....A ..... **53.** Tends to pet animals with too much force.
N ..... O .....F.....A ..... **54.** Bumps or pushes other children.
N ..... O .....F.....A ..... **55.** Chews on toys, clothes, or other objects more than other children.

BALANCE AND MOTION *This child...*

N ..... O .....F.....A ..... **56.** Seems excessively fearful of movement, such as going up and down stairs or riding swings, teeter-totters, slides, or other playground equipment.
N ..... O .....F.....A ..... **57.** Avoids balance activities, such as walking on curbs or on uneven ground.
N ..... O .....F.....A ..... **58.** Falls out of a chair when shifting his or her own body.
N ..... O .....F.....A ..... **59.** Fails to catch himself or herself when falling.
N ..... O .....F.....A ..... **60.** Seems not to get dizzy when others usually do.
N ..... O .....F.....A ..... **61.** Spins and whirls his or her body more than other children.
N ..... O .....F.....A ..... **62.** Shows distress when his or her head is tilted away from the upright, vertical position.
N ..... O .....F.....A ..... **63.** Shows poor coordination and appears to be clumsy.
N ..... O .....F.....A ..... **64.** Leans on other people or furniture when sitting or when trying to stand up.
N ..... O .....F.....A ..... **65.** Rocks his or her body when awake and sitting up.
N ..... O .....F.....A ..... **66.** Seems afraid to descend stairs or hills.

PLANNING AND IDEAS *This child...*

N ..... O .....F.....A ..... **67.** Has trouble figuring out how to carry multiple objects at the same time.
N ..... O .....F.....A ..... **68.** Seems confused about how to put away materials and belongings in their correct places.
N ..... O .....F.....A ..... **69.** Becomes confused about the proper sequence of actions when doing familiar, everyday routines, such as getting dressed or going to bed.
N ..... O .....F.....A ..... **70.** Fails to complete tasks with multiple steps.
N ..... O .....F.....A ..... **71.** Has difficulty imitating demonstrated actions, such as movement games or songs with motions.
N ..... O .....F.....A ..... **72.** Has difficulty copying another child or an adult when building with blocks.
N ..... O .....F.....A ..... **73.** Has trouble coming up with new ideas during play activities.
N ..... O .....F.....A ..... **74.** Tends to play the same activities over and over, rather than shift to new activities when given the chance.
N ..... O .....F.....A ..... **75.** Has trouble climbing in and out of the car seat.

APPENDIX H

Informed Consent

TEXAS WOMAN'S UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

Title: Idiopathic Toe Walking and Postural Control: Going Beyond the Toes

Investigator: Jessica McHugh, OTR/L .....jmchugh@twu.edu 712/xxx-xxxx
Advisor: Mary Frances Baxter, OTR, PhD ..... MBaxter@twu.edu 713/xxx-xxxx

Explanation and Purpose of the Research

You and your child are being asked to participate in a research study conducted by Jessica McHugh,OTR/L. This is a pilot study looking at toe walking without an underlying diagnosis (idiopathic toe walking) as part of a PhD program at Texas Woman's University. The purpose of this research is to determine if there is a difference in the postural control and sensory processing of children who are idiopathic toe walkers, those with autism who toe walk, and those who are not toe walkers. The results of this study will be used to verify whether activities focusing on postural control and body awareness, would be a good treatment option for toe walking. You and your child have been asked to participate in this study because: (1) your child is an idiopathic toe walker, (2) your child has autism and walks on toes, or (3) your child will participate as a part of a control group.

Description of Procedures

As a participant in this study you will be asked to answer questions about your child's toe walking and developmental history and complete a questionnaire on how your child processes sensory information. Your child's Height and weight, and ankle, knee and hip movement will be measured. Your child then will be asked to complete 4 brief activities: kneeling by a wall and reaching forward, squatting against a wall, laying on his/her back and curling knees/head towards his/her chest, and laying on his/her back to fly like superman. In order to be a participant in this study, you must have a child who walks on toes with no underlying cause, has autism and walks on toes, or is an age-match for children in the other two groups.

Potential Risks

The researcher will ask you questions about your child's development history and you will fill out a questionnaire about how your child processes sensory information. A possible risk in this study is discomfort with the questions you are asked. If you become tired, you may take breaks as needed. You may also stop answering questions at any time and end the interview.

_____
Initials

Your child may be uncomfortable interacting with an unfamiliar individual. The investigator will approach your child by engaging him/her in activities such as games prior to starting session in order to lessen any anxiety. Your child can ask questions at any time during the study and you or your child can ask to stop the session at any time.

Another risk in this study is injury to your child. This risk is low, as your child will not be asked to do any difficult physical tasks. The risk will be further decreased by close supervision by the investigator at all times during the evaluation.

A final risk in this study is loss of confidentiality. Confidentiality will be protected to the extent that is allowed by law. The interview will be held in a private room that you and the researcher have agreed upon. Only your child's first name will be written down. The results of the study will be reported in scientific magazines or journals but your name/your child's name or any other identifying information will not be included.

The researcher will try to prevent any problem that could happen because of this research. You should let the researcher know at once if there is a problem and they will help you. However, TWU does not provide medical services or financial assistance for injuries that might happen because you are taking part in this research.

Participation and Benefits

Your involvement in this study is completely voluntary and you may withdraw from the study at any time. Following the completion of the study your child will be able to pick out a small prize to thank him/her for participating. If you would like to know the results of this study, they will also be mailed to you.*

Questions Regarding the Study

You will be given a copy of this signed and dated consent form to keep. If you have any questions about the research study you should ask the researchers; their phone numbers are at the top of this form. If you have questions about your rights as a participant in this research or the way this study has been conducted, you may contact the Texas Woman's University Office of Research and Sponsored Programs at 940-898-3378 or via e-mail at IRB@twu.edu.

_____ _____

Signature of Participant Date

*If you would like to know the results of this study tell us where you want them to be sent:

Email: _____
or
Address:

_____

_____

APPENDIX I

Observation Sheet

Toe Walking Study

Observation Sheet

Today's Date: _____

Child's Age: _____years_____months

Child's First Name: _____

Gender: ☐ Male ☐ Female

Group: ☐ Toe Walking
☐ Control Group

Additional Information:

Position	Impressions	Observation
Schilder's Arm Extension Test	**Eyes Closed**: *Arm Position* ☐ Arm remain at shoulder level or fall less than 5 degrees with head turn ☐ Arms fall more than 5 degrees with head turn *Disassociation* ☐ Arms remain at midline with head turn to B directions ☐ Arms follow head turn to ___ side ☐ Arms follow head turn to B side	**Assuming position** ☐Head turns smoothly with input from PI ☐Neck is stiff and hard to move ☐Requires no more than one verbal cues to keep hands up ☐Cannot maintain position with 1 verbal cue to keep hands up **Other Observations:**
Squatting against wall	_____ Seconds	**Initial Position** ☐ On toes

	maintained	□ Out-toeing □ Knees together □ Other: **Assuming position** □Assumes position without difficulty □Assumes position with verbal cues □Assumes position with physical cues **Cues needed to maintain Position** □ No verbal cues to maintain position □ ≤ 2 verbal cues to maintain position □ Ended position due to > 2 verbal cues **Position ended due to:** □ Multiple cues for position □ Sliding down against wall □ Request to stop **Other Observations:**
Supine Flexion	_____ Seconds maintained	**Assuming position** □Assumes position without difficulty □Assumes position with verbal cues □Assumes position with physical cues **Upper/Lower Body** □ Upper and lower body flexion occurs at the same time □ Upper body occurs first □ Lower body occurs first **Stabilization Strategies** □ No stabilization strategies utilized □ Stabilization or movement strategy: _____ **Other Observations:**
Prone Extension	_____ Seconds	**Assuming position** □Assumes position without difficulty

	maintained	□Assumes position with verbal cues □Assumes position with physical cues **Upper/Lower Body** □ Upper and lower body flexion occurs at the same time □ Upper body occurs first □ Lower body occurs first **Stabilization Strategies** □ No stabilization strategies utilized □ Stabilization or movement strategy: _____ **Other Observations:**

APPENDIX J

Study Results by Participant

Toe Walker
AGE: 4:1 Sex: F
Control
AGE: 4.0 Sex: F

Test	Toe Walker	Control
Schilder's	*Arm Position* □ Arm remain at shoulder level or fall less than 5 degrees with head turn ý Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side	*Arm Position* □ Arm remain at shoulder level or fall less than 5 degrees with head turn ý Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side
Wall Squat	15 seconds	24 seconds
Supine Flexion	9 seconds	9 seconds
Prone Extension	5 seconds	18 seconds

SPM-P	Toe Walker	Control
Social	Typical	Typical
Vision	Typical	Some problems
Hearing	Typical	Definite Dysfun
Touch	Typical	Some Problems
Body Awareness	Typical	Some Problems
Balance and Motion	Typical	Some Problems
Planning and Ideas	Typical	Some Problems
Total	Typical	Some Problems

Toe Walker
AGE: 4:0 Sex: F
Control
AGE:3:10 Sex: F

Test	Toe Walker	Control
Schilder's	*Arm Position* □ Arm remain at shoulder level or fall less than 5 degrees with head turn ý Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side
Wall Squat	11 seconds	24 seconds
Supine Flexion	9 seconds	19 seconds
Prone Extension	3 seconds	22 seconds

SPM-P	Toe Walker	Control
Social	Typical	Typical
Vision	Typical	Typical
Hearing	Typical	Typical
Touch	Typical	Typical
Body Awareness	Typical	Typical
Balance and Motion	Typical	Typical
Planning and Ideas	Typical	Typical
Total	Typical	Typical

Toe Walker
AGE: 4:5 Sex: F
Control
AGE: 4:2 Sex: F

Test	Toe Walker	Control
Schilder's	*Arm Position* □ Arm remain at shoulder level or fall less than 5 degrees with head turn ý Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side	*Arm Position* □ Arm remain at shoulder level or fall less than 5 degrees with head turn ý Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side
Wall Squat	32 seconds	43 seconds
Supine Flexion	36 seconds	26 seconds
Prone Extension	19 seconds	23 seconds

SPM-P	Toe Walker	Control
Social	Some Problems	Typical
Vision	Some Problems	Typical
Hearing	Some Problems	Typical
Touch	Some Problems	Typical
Body Awareness	Definite Dysfunc	Some Problems
Balance and Motion	Definite Dysfunc	Typical
Planning and Ideas	Definite Dysfunc	Typical
Total	Definite Dysfunc	Typical

Toe Walker
AGE: 5:3 Sex: M
Control
AGE: 5:2 Sex: M

Test	Toe Walker	Control
Schilder's	*Arm Position* □ Arm remain at shoulder level or fall less than 5 degrees with head turn ý Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side
Wall Squat	11 seconds	27 seconds
Supine Flexion	15 seconds	15 seconds
Prone Extension	28 seconds	19 seconds

SPM-P	Toe Walker	Control
Social	Typical	Typical
Vision	Typical	Some problems
Hearing	Typical	Typical
Touch	Typical	Typical
Body Awareness	Typical	Typical
Balance and Motion	Typical	Some Problems
Planning and Ideas	Typical	Typical
Total	Typical	Some Problems

Toe Walker
AGE: 5:9 Sex: F
Control
AGE: 5:4 Sex: F

Test	Toe Walker	Control
Schilder's	*Arm Position* □ Arm remain at shoulder level or fall less than 5 degrees with head turn ý Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions Slight movement toward R □ Arms follow head turn to ___ side □ Arms follow head turn to B side
Wall Squat	18 seconds	39 seconds
Supine Flexion	36 seconds	62 seconds
Prone Extension	33 seconds	78 seconds

SPM-P	Toe Walker	Control
Social	Typical	Typical
Vision	Some Problems	Some problems
Hearing	Some Problems	Typical
Touch	Definite Dysfunction	Typical
Body Awareness	Some Problems	Typical
Balance and Motion	Typical	Typical
Planning and Ideas	Typical	Typical
Total	Some Problems	Typical

Toe Walker
AGE: 6:6 Sex: F
Control
AGE: 6:3 Sex: F

Test	Toe Walker	Control
Schilder's	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions Slight movement B directions □ Arms follow head turn to ___ side □ Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions Slight movement toward R □ Arms follow head turn to ___ side □ Arms follow head turn to B side
Wall Squat	55 seconds	62 seconds
Supine Flexion	11 seconds	49 seconds
Prone Extension	48 seconds	95 seconds

SPM	Toe Walker	Control
Social	Typical	Typical
Vision	Typical	Typical
Hearing	Typical	Some Problems
Touch	Typical	Typical
Body Awareness	Typical	Some Problems
Balance and Motion	Typical	Some Problems
Planning and Ideas	Typical	Typical
Total	Typical	Some problems

Toe Walker
AGE: 7:5 Sex: F
Control
AGE: 7:5 Sex: F

Test	Toe Walker	Control
Schilder's	*Arm Position* □ Arm remain at shoulder level or fall less than 5 degrees with head turn ý Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions Slightly toward R □ Arms follow head turn to ___ side □ Arms follow head turn to B side
Wall Squat	42 seconds	47 seconds
Supine Flexion	17 seconds	55 seconds
Prone Extension	57 seconds	102 seconds

SPM-P	Toe Walker	Control
Social	Typical	Typical
Vision	Typical	Typical
Hearing	Typical	Typical
Touch	Typical	Typical
Body Awareness	Typical	Typical
Balance and Motion	Some Problems	Typical
Planning and Ideas	Typical	Typical
Total	Typical	Typical

Toe Walker
AGE: 7:6 Sex: F
Control
AGE: 7:9 Sex: F

Test	Toe Walker	Control
Schilder's	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions ý Arms follow head turn to _L__ side □ Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side □ Arms follow head turn to B side
Wall Squat	30 seconds	72 seconds
Supine Flexion	16 seconds	56 seconds
Prone Extension	18 seconds	55 seconds

SPM	Toe Walker	Control
Social	Typical	Typical
Vision	Typical	Typical
Hearing	Typical	Typical
Touch	Some Problems	Typical
Body Awareness	Some Problems	Typical
Balance and Motion	Some Problems	Typical
Planning and Ideas	Typical	Typical
Total	Some Problems	Typical

Toe Walker
AGE: 7:1 Sex: M
Control
AGE: 7:1 Sex: M

Test	Toe Walker	Control
Schilder's	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions ý Arms follow head turn to _L__ side □ Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions Slight movement toward R □ Arms follow head turn to ___ side □ Arms follow head turn to B side
Wall Squat	33 seconds	44 seconds
Supine Flexion	35 seconds	43 seconds
Prone Extension	42 seconds	58 seconds

SPM	Toe Walker	Control
Social	Some Problems	Some Problems
Vision	Typical	Typical
Hearing	Some Problems	Typical
Touch	Typical	Typical
Body Awareness	Some Problems	Some Problems
Balance and Motion	Some Problems	Typical
Planning and Ideas	Typical	Typical
Total	Some Problems	Typical

Toe Walker
AGE: 7:3 Sex: M
Control
AGE: 7:2 Sex: M

Test	Toe Walker	Control
Schilder's	*Arm Position* □ Arm remain at shoulder level or fall less than 5 degrees with head turn ý Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions Slight movement toward L side □ Arms follow head turn to ___ side □ Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side
Wall Squat	16 seconds	77 seconds
Supine Flexion	17 seconds	136 seconds
Prone Extension	45 seconds	88 seconds

SPM	Toe Walker	Control
Social	Typical	Typical
Vision	Typical	Typical
Hearing	Typical	Typical
Touch	Typical	Typical
Body Awareness	Some Problems	Typical
Balance and Motion	Typical	Typical
Planning and Ideas	Definite Dysfunction	Typical
Total	Typical	Typical

Toe Walker
AGE: 8:0 Sex: M
Control
AGE: 8:1 Sex: M

Test	Toe Walker	Control
Schilder's	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions Slight moment toward L □ Arms follow head turn to ___ side □ Arms follow head turn to B side
Wall Squat	62 seconds	66 seconds
Supine Flexion	61 seconds	18 seconds
Prone Extension	61 seconds	38 seconds

SPM	Toe Walker	Control
Social	Typical	Typical
Vision	Typical	Typical
Hearing	Typical	Typical
Touch	Typical	Typical
Body Awareness	Typical	Typical
Balance and Motion	Typical	Typical
Planning and Ideas	Typical	Typical
Total	Typical	Typical

Toe Walker
AGE: 8:0 Sex: F
Control
AGE: 7:11 Sex: F

Test	Toe Walker	Control
Schilder's	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions Slight movement toward L □ Arms follow head turn to ___ side □ Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side □ Arms follow head turn to B side
Wall Squat	16 seconds	51 seconds
Supine Flexion	28 seconds	30 seconds
Prone Extension	40 seconds	62 seconds

SPM	Toe Walker	Control
Social	Typical	Some Problems
Vision	Typical	Typical
Hearing	Typical	Some Problems
Touch	Typical	Some Problems
Body Awareness	Typical	Some Problems
Balance and Motion	Typical	Typical
Planning and Ideas	Typical	Typical
Total	Typical	Some Problems

Toe Walker
AGE: 8:2 Sex: M
Control
AGE: 8:3 Sex: M

Test	Toe Walker	Control
Schilder's	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions Slight movement toward L □ Arms follow head turn to ___ side □ Arms follow head turn to B side
Wall Squat	15 seconds	60 seconds
Supine Flexion	30 seconds	51 seconds
Prone Extension	20 seconds	83 seconds

SPM	Toe Walker	Control
Social	Typical	Typical
Vision	Typical	Typical
Hearing	Some Problems	Typical
Touch	Some Problems	Typical
Body Awareness	Some Problems	Typical
Balance and Motion	Some Problems	Typical
Planning and Ideas	Some Problems	Typical
Total	Some Problems	Typical

Toe Walker
AGE: 12:1 Sex: M
Control
AGE: 12:1 Sex: M

Test	Toe Walker	Control
Schilder's	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* □ Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side ý Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side □ Arms follow head turn to B side
Wall Squat	35 seconds	75 seconds
Supine Flexion	20 seconds	120 seconds
Prone Extension	60 seconds	120 seconds

SPM	Toe Walker	Control
Social	Typical	Some Problems
Vision	Some Problems	Typical
Hearing	Some Problems	Typical
Touch	Some Problems	Typical
Body Awareness	Typical	Typical
Balance and Motion	Some Problems	Typical
Planning and Ideas	Some Problems	Typical
Total	Some Problems	Typical

Toe Walker
AGE: 13:2 Sex: F
Control
AGE: 13:5 Sex: F

Test	Toe Walker	Control
Schilder's	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side □ Arms follow head turn to B side	*Arm Position* ý Arm remain at shoulder level or fall less than 5 degrees with head turn □ Arms fall more than 5 degrees with head turn *Disassociation* ý Arms remain at midline with head turn to B directions □ Arms follow head turn to ___ side □ Arms follow head turn to B side
Wall Squat	64 seconds	91 seconds
Supine Flexion	47 seconds	125 seconds
Prone Extension	76 seconds	91 seconds

SPM	Toe Walker	Control
Social	Typical	Typical
Vision	Typical	Typical
Hearing	Typical	Typical
Touch	Typical	Typical
Body Awareness	Typical	Typical
Balance and Motion	Typical	Typical
Planning and Ideas	Typical	Typical
Total	Typical	Typical